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EFFECT OF MALATHION ON THE FREE AMINO ACIDS IN THE HAEMOLYMPH OF *DYSDERCUS KOENIGII* (HEMIPTERA - PYRRHOCORIDAE)

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(Received 25 October 1981)

Free amino acids of haemolymph of *Dysdercus koenigii* were determined qualitatively by two-dimensional paper chromatography and thereafter quantitatively by spectrophotometer. Fifteen amino acids were detected of which proline occurred in highest concentration followed by glycine. Other amino acids showed quantitative variations. A marked decline in the concentration of all free amino acids was observed one hour after malathion treatment. In the next successive hour their concentration decreased further except glutamine which increased.

(*Key words:* haemolymph free amino acids, *Dysdercus koenigii*, malathion treatment)

INTRODUCTION

Insects are characterised by the high level of amino acids in their haemolymph (BUCK, 1953; FLORKIN, 1959; GILMOUR, 1961, 1965; WYATT, 1961; CHEN, 1962, 1966; CLEMENTS, 1963). The high concentration of free amino acids is believed to play an important role in osmoregulation as suggested by BISHOP *et al.* (1926) and BEADLE & SHAW (1950). Free amino acids may be concerned with protein synthesis (BUCK, 1953), energy production for flight and also in cocoon construction (WYATT, 1961).

Insecticide has been shown to affect the level of free amino acids in the tissues including haemolymph of insects. Malathion was chosen as the test insecticide because it does not inhibit the Krebs cycle (O'BREIN, 1957). WINTERINGHAM & HARRISON (1956) by means of radiometric techniques, found evidence for the accumulation of glutamine in the thorax of adult houseflies treated with DFP. MANSINGH (1964) has studied the effect of malathion on the haemolymph of cockroach.

The primary aim of the present investigation was to determine the effect of malathion on the concentration of free amino acids in the haemolymph of *Dysdercus koenigii* at fixed time intervals.

MATERIALS AND METHODS

Adults of *Dysdercus koenigii* (Fabricius) were collected locally. Haemolymph was obtained by cutting the coxae of the legs. In all, 0.5 ml of haemolymph was pooled and deproteinized according to the method of PANT & AGRAWAL (1964). All chemicals used were of analytical reagent grade. Extracts were applied as compact spots on Whatman. No. 1 filter paper sheet (40 cm × 40 cm). Two-dimensional paper chromatography was done according to the method of SMITH & AGIZA (1951). The chromatograms were first developed with *n*-butanol: glacial acetic acid: distilled water (4 : 1 : 5) for 6 hr. The second solvent was made with phenol saturated with distilled water. Spots were developed by ninhydrin and identified with the predetermined Rf values of the known amino acid.

To determine the concentration of free amino acids, ninhydrin coloured spots were eluted.

The spots were placed in tubes separately to which was added one ml NaOH (neutralized with phenolphthalene), one ml citrate buffer (pH 5) and two ml ninhydrin solution. The tubes were then placed in boiling water, to them was added one ml stannous chloride solution, this produced red colour which after fifteen minutes changed into purple. The tubes were then kept in a dark place for 15 minutes, 5 ml *n*-butanol was added in each tube, they were then shaken and kept ready for estimation. The optical density of solution was measured using Carl Zeiss Universal Spectrophotometer (Model VSU-1) at 750m$_\mu$ and at 440m$_\mu$ (only for proline) against a blank extract prepared from a piece of the same filter paper of the same areas. The concentration of the separated amino acids was calculated from standard curves previously prepared using standard amino acid solutions chromatographed for the same period using the same solvent,

Known quantity (LD_{50}) of malathion was sprayed on the insects and haemolymgh was pooled after the lapse of one hour of insecticidal treatment by cutting the coxae. Again after the lapse of one hour and forty five minutes the haemolymph was collected for chromatographic separation and quantitative estimation was carried out by the processes described above.

RESULTS

Fifteen amino acids were identified on the two dimensional paper chromatogram in *Dysdercus koenigii*. Table shows the concentration of all free amino acids. Proline showed the highest concentration, the next abundant free amino acid was glycine. Valine and alanine also occurred at high concentration. Among them phenylalanine occurred in lower concentration. The concentration of all free amino acids changed by applying malathion. After one hour of insecticidal treatment, it was observed that all fifteen free amino acids showed lesser concentration than the concentration found in the untreated insects. Again

TABLE 1. The effect of malathion toxicity on the concentration of free amino acids in haemolymph of *Dysdercus koenigii*.

(Concentration in $_\mu$ mol/100 ml of haemolymph)

Amino acids	Concentration		
	In normal insect	60 minutes after malathion poisoning	105 minutes after malathion poisoning.
Glycine	110.00	64.00	44.53
Alanine	84.63	64.49	29.77
Serine	66.23	48.19	40.00
Threonine	58.59	29.41	22.86
Valine	70.60	33.81	25.13
Leucine	56.18	37.02	25.04
Iso-leucine	58.32	38.02	25.04
Glutamic acid	42.41	20.41	13.88
Glutamine	46.25	21.92	25.21
Proline	247.72	88.35	69.22
Lysine	56.50	34.59	30.68
Arginine	40.99	34.94	29.59
Histidine	58.90	22.97	20.00
Cysteine	49.75	39.26	19.17
Phenylalanine	33.17	26.36	16.61

after 1 hour 45 minutes of malathion poisoning, it was found that all the free amino acids showed a further decline in concentration, except glutamine. Its concentration, though higher than after one hour among treated insects, was less than the concentration in untreated ones.

DISCUSSION

All of the amino acids commonly found in proteins have been identified in the insect's blood although some, such as methionine, cysteine, serine, hydroxyproline and tryptophan are found only in a few insects or in low concentration (GILMOUR, 1965). The work was reviewed by MALUF (1939), WIGGLESWORTH (1939, 1954), MELANBY (1939), CHANVIN (1949), BUCK (1953), WYATT (1961) and CHEN (1962). Besides participating in osmoregulation and buffering of the blood to some extent, the main function of the amino acids in the heamolymph is either to serve as units for protein-synthesis or further metabolism. MENGLE & CASIDA (1960) did not find any significant differences in the rates of penetration of malathion between susceptible and resistant houseflies. MANSINGH (1964) also observed the effect of malathion on the free amino acids present in the haemolymph of cockroach.

In the present work, proline concentration was much higher than that of the other amino acids. The same situation has been reported by BURSELL (1963) in *G. morsitans* (Diptera) and BARRET (1974) in *R. prolixus*. It has also been found abundantly in the whole body of female mosquito, *A. aegypti* (THAYER & TERIAN, 1970) and has been proposed as an energy source during the flight in *G. morsitans* (BORSELL, 1963, 1966). It has been suggested that proline plays the role of a readily available metabolizable energy reserve for the flight and movements (BALOGUN, 1974). A great number of amino acids like alanine, glutamine, glycine and proline are known to have important roles in the synthesis of cuticle proteins, chitin and other constituents of the cuticle.

Malathion poisoned insects show depletion of all the amino acids. The magnitude of depletion of these amino acids was directly dependent upon the degree of toxicity. CORRIGAN & KEARNS (1963) observed that the concentration of glutamine and proline in the haemolymph of DDT poisoned cockroaches varies inversely with increase in toxicity. These roaches catabolized more of free glycine too. The present observations suggest that the level of free amino acids in the treated insects are influenced by the amount of insecticides used for poisoning (lethal dose) and the time of evaluation of the toxic effects.

The correlation between the degree of toxicity and the reduction of amino acids indicate that the depletion of amino acids was an indirect effect of poisoning.

Thus, it is concluded that the depletion of amino acids was mainly a consequence of the higher metabolic activity of the poisoned insects. The decrease in the levels of amino acids is due to an imbalance between the rates of anabolism and catabolism in the poisoned insects. Since glutamine enters into so many metabolic processes (MEISTER, 1957), it is difficult to explain the increase in its concentration in the second stage after the insecticidal treatment.

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CONTROL OF BRINJAL SHOOT- AND FRUIT-BORER *LEUCINODES ORBONALIS* GUEN. (PYRALIDAE : LEPIDOPTERA)

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(Received 7 October 1981)

Seven insecticides, namely carbaryl @ 1 kg ai/ha, endosulfan @ 0.7 kg ai/ha, quinalphos, fenitrothion, chlorpyriphos, phenthoate and methomyl each @ 0.5 kg ai/ha were tried against brinjal shoot- and fruit-borer in 1977 and 1978. Among them carbaryl and endosulfan were found to be the most effective in reducing the damage of shoots and fruits and thereby increasing the yield of brinjal fruits. So far as cost-benefit ratio of different insecticides is concerned, carbaryl and endosulfan recorded the highest in comparison to others.

(*Key words:* brinjal shoot- and fruit-borer, *Leucinodes orbonalis*, chemical control)

INTRODUCTION

The brinjal *(Solanum melongena;* L.) occupies an important place in vegetable cultivation due to its high yielding capacity and is widely grown in Bihar State. Like other crops, the brinjal production is also threatened by a large number of pests among which the shoot- and fruit-borer, *(Leucinodes orbonalis* Guen.) is a major one. Its extent of damage touches as high as 30 to 80 per cent (SINGH & SINHA, 1963—1964) in Bihar conditon. SINGH & SINHA, (1963—1964) and LAL & AHMAD (1965) reported the effectiveness of chlorinated hydrocarbon against this pest. According to JOTWANI & SWARUP (1963) and DAVID (1963) carbamate and organophosphate insecticides are quite effective against this pest.

Though this economically important pest received much attention in other parts of the country, no systematic effort appears to have been made in Bihar to tackle this insect. As the fruits are harvested at short intervals, an attempt has been made to screen some potent organophosphate and carbamate insecticides with short residual toxicity.

MATERIALS AND METHODS

An experiment was laid out at the vegetable farm, A. R. I., Sabour in *kharif* season during the year 1977 and 1978 with variety *Pusa purple long*. There were eight treatments including control with three replications in a randomised block design. The plot size was 4.80 × 3 m and spacing between plant to plant and row to row was kept at 60 cm. The treatment comprised of seven insecticides sprayed six times, the common name and dosages of which are shown in Table 1. The first spraying was given at 30 days after transplanting and the subsequent five sprayings were given at fortnight intervals. The spray material was applied @ 750 l and 825 l per hectare in first and second spraying time and 1000 l in subsequent spraying by a hand compression sprayer. The plants were sprayed till the point of run-off. The observations were recorded in respect of total number of shoots and infested shoots before sprayings. The fruits were harvested at weekly intervals and the total number of fruits as well as number of fruits infested at each picking were recorded to obtain the percentage of fruit-damage. The yield of healthy fruits in weight per treatment was also recorded after each

picking and presented in Table 1. The data were analysed statistically. Economics of different insecticides tried in both the years 1977 and and 1978 have been calculated and presented in Table 2.

RESULTS AND DISCUSSION

Perusal of the data presented in Table 1 indicates that all the insecticides were effective in reducing the borer infestation on shoots and fruits of brinjal and were significantly superior over control. Treatment with carbaryl was found to be most effective and superior to all the treatments except endosulfan in 1977 whereas in 1978 carbaryl was at par with endosulfan and methomyl in reducing the damage of shoots are concerned. Carbaryl had minimum shoot infestation of 7.4% and 11.94% during the respective years.

Carbaryl which produced the least infested fruits i. e., 9.35% and 6.10% in 1977 and 1978 respectively in comparison to other insecticides, was found superior to other treatments except endosulfan. However, endosulfan was at par with quinalphos and methomyl in years under investigation.

The yield data as presented in Table 1 indicate that all the treatments were significantly superior to control in producing higher yields. Among the insecticides, carbaryl which gave 125.93 qt of yield per hectare was superior to all the other insecticidal treatments except endosulfan which had 117.75 qt /ha in 1977, followed by methomyl, quinalphos, chlorpyriphos fenitrothion and phenthoate. However quinalphos, endosulfan and methomyl were at par among themselves. In the year 1978, carbaryl with 107.99 qt of yield was found to be at par with endosulfan having 92.50 qt of yield and was superior to other treatments. Quinalphos and methomyl were at par with endosulfan while other insecticides as fenitrothion, chlorpyriphos and phenthoate were at par with the untreated control which produced 73.97 qt of yield per hectare.

TABLE 1. Efficacy of different insecticides against *Leucinodes orbonalis*

Treatments	Dosages kg ai/ ha	1977			1978		
		Percentage shoot damage	Percentage fruit damage	Yield q/ha	Percentage shoot damage	Percentage fruit damage	Yield q/ha
Carbaryl	1.00	7.40(15.72)	9.35(17.83)	125.93	11.94(20.19)	6.10(14.12)	107.97
Quinalphos	0.5	14.68(22.44)	11.35(19.61)	113.18	14.65(22.50)	10.15(18.50)	90.62
Endosulfan	0.7	8.60(16.82)	10.25(18.72)	117.75	12.27(20.67)	9.50(17.72)	92.50
Fenitrothion	0.5	18.48(25.42)	15.25(23.03)	105.72	17.42(24.66)	16.25(23.61)	84.35
Chlorpyriphos	0.5	17.15(24.42)	14.30(22.26)	106.33	16.20(23.71)	14.25(22.36)	85.35
Phenthoate	0.5	19.15(25.94)	16.50(24.02)	103.76	18.65(25.59)	24.75(29.77)	80.73
Methomyl	0.5	12.67(20.84)	11.25(19.61)	113.91	12.46(20.68)	10.20(18.55)	90.19
Control	—	25.70(30.39)	28.31(32.17)	87.61	21.21(27.40)	34.50(35.95)	73.97
Note: Figures in parentheses indicate the transformed value.							
S E/plot ±		1.11	1.46	5.58	1.52	2.08	10.53
CD at 5%		1.95	1.67	8.22	2.24	3.64	15.49

TABLE 2. Economics of different insecticides against *Leucinodes orbonalis* Guen. (1977 & 1978).

Insecticides	Avg. yield in 1977 & 1978 q/ha	Additional increase over control q/ha	Price of fruits Rs 100.00 per qt	Cost of insecticides & operational charges (Rs/ha)	Net return over control Rs/ha	Cost benefit ratio
Carbaryl	116.95	36.16	3616.00	540.00	3076.00	1:5.6
Quinalphos	101.90	21.11	2111.00	960.00	1151.00	1:1.1
Endosulfan	105.12	24.33	2433.00	780.00	1653.00	1:2.1
Fenitrothion	95.03	14.24	1425.00	570.00	855.00	1:1.5
Chlorpyriphos	95.84	15.05	1505.00	1200.00	305.00	1:0.2
Phenthoate	92.25	11.45	1145.00	450.00	695.00	1:1.5
Methomyl	102.50	21.71	2171.00	900.00	1271.00	1:1 4
Control	80.79	—	—	—	—	—

Thus the performance of carbaryl was found to be most promising in minimising the shoot- and fruit- infestation and in giving higher yield over other treatments except endosulfan in both the years of investigation. This finding in respect of carbaryl @ 1.0 kg ai/ha is in accordance with the findings of JOTWANI & SWARUP (1963) and DAVID (1963).

The economics of different insecticidal treatments presented in Table 2 has revealed that an investment of Rs 540.00 as cost of carbaryl 50 W P including the operational charges gave a net return of Rs 3076.00 with a cost-benefit ratio of 1:5.6 while endosulfan 35 E C and its operation charges costing Rs 780.00 gave a net profit of Rs. 1653.00 having a cost-benefit ratio of 1:2.1. Chlorpyriphos which cost Rs 1200.00 with its operations charge gave the lowest return of Rs 305.00 only and its cost-benefit ratio was 1:0 2. The other insecticides also could not account moderate cost-benefit ratio due to less effectiveness and high cost.

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RELATIVE EFFICACY OF SOME ANTIFEEDANTS AND DETERRENTS AGAINST INSECT PESTS OF STORED PADDY

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The relative efficacy of eleven antifeedants and deterrents in protecting stored paddy from infestation by *Rhizopertha dominica*, *Sitotroga cerealella* and common pests occurring in godowns was studied in separate sets of experiments. Against *R. dominica* neem extract 1% and 0.5%, neem oil 1% and coconut oil 1% gave good protection for six months. In the case of *S. cerealella*, neem extract 1% was found to be the best. Neem extract 1% and coconut oil 1% reduced the damage of grains in godowns caused by various pests. Coconut oil adversely affected germination of stored grains. On cost basis and on the basis of effect on germination, neem extract 0.5% may be chosen for protecting stored paddy from insect infestation.

(*Key words: Rhizopertha dominica, Sitotroga cerealella,* antifeedants, deterrents)

INTRODUCTION

Antifeedants and deterrents have recently been suggested against insects attacking stored commodities particularly because of the safety involved. Neem seed kernel powder, neem extract, groundnut oil, vegetable oils and paddy husk charcoal were found to give protection to the paddy seeds from stored pests (JOTWANI & SIRCAR, 1965; PRADHAN & JOTWANI, 1968; ABRAHAM *et al.*, 1972; JILANI & MALIK, 1973; SAVITHRI, 1974; NAIR, 1976; SCHOONHOVEN, 1978; VARMA & PANDEY, 1978; NARASIMHAN & KRISHNAMOORTHY, 1944). In the present studies, the relative efficacy of eleven antifeedants or deterrents against the lesser grain borer, *Rhizopertha dominica*, Angoumois grain moth, *Sitotroga cerealella* and the common pests occurring in godowns were assessed through separate experiments.

MATERIALS AND METHODS

The insects used for the experiments, *R. dominica* and *S. cerealella* were reared in the laboratory on conditioned paddy grains. The different antifeedants and deterrents (Table 1) were used at 1% and 0.5% concentrations. Oil cakes and paddy husk charcoal were powdered well and directly mixed with pre-conditioned grains while oils were mixed with grains by turning them in a large bottle so as to give a uniform spread. After thorough mixing, the treated grains were filled in gunny bags (30×20cm) and the openings were stitched properly. Then they were arranged in single layer, at random in dealwood boxes (90 × 90 × 75 cm) each having the capacity to hold 24 filled bags referred to above. Bags similarly filled with untreated grains and arranged among the treated lots at random served as control. Each treatment was replicated thrice and one box was used for keeping one replication each of the treatments. Separate lots were used for infesting the treated grains with *R. dominica*, *S. cerealella* and for exposure in godowns.

Two hundred adult animals were collected from the insect cultures maintained in the laboratory and were released into each box at biweekly intervals, thus ensuring a high pest population around the treated bags. Samples were drawn from the bags at monthly intervals and the damaged ones in lots of thousand grains in each replication were counted and recorded. From these the

TABLE 1. Mean germination percentage and mean percentage of infestation of paddy grains mixed with antifeedants and deterrents both under artificial and natural infestation conditions.

Treatments	Artifical infestation				Natural infestation		Germination percentage	
	R. dominica		*S. cerealella*		Common pests in store			
	3rd month	6th month	3rd month	6th month	3rd month	6th month	3rd month	6th month
Neem cake 1%	4.43 (12.142)	13.73 (21.750)	3.97 (11.481)	8.70 (17.152)	3.20 (10.292)	6.67 (14.956)	66.67 (54.739)	50.00 (45.000)
,, 0.5%	6.47 (14.723)	14.10 (22.049)	5.43 (13.471)	9.67 (18.110)	3.20 (10.292)	7.43 (15.811)	68.67 (55.965)	51.00 (45.573)
Neem oil 1%	2.70 (9.776)	9.30 (17.745)	2.07 (8.245)	5.77 (13.886)	1.90 (7.911)	4.83 (12.696)	64.67 (53.537)	48.00 (43.854)
,, 0.5%	4.63 (12.419)	10.80 (19.184)	3.37 (10.556)	6.77 (15.073)	1.97 (8.054)	6.23 (14.443)	64.00 (53.139)	50.00 (45.00)
Neem extract 1%	1.80 (7.696)	6.30 (14.532)	2.03 (8.188)	5.30 (13.302)	1.07 (5.899)	3.67 (11.028)	65.33 (53.949)	52.67 (46.532)
,, 0.5%	3.00 (9.962)	7.07 (15.397)	2.77 (9.570)	6.23 (14.455)	2.13 (8.395)	5.33 (13.306)	62.33 (52.162)	52.67 (46.532)
Marotty cake 1%	8.17 (16.604)	16.23 (23.755)	6.40 (14.648)	12.57 (20.760)	5.00 (12.914)	12.73 (20.903)	63.33 (52.748)	55.67 (48.255)
,, 0.5%	8.50 (16.948)	16.37 (23.562)	6.20 (14.413)	12.93 (21.071)	6.10 (14.297)	10.37 (18.776)	64.00 (53.155)	53.33 (46.919)
Punnai cake 1%	7.93 (16.356)	16.30 (23.809)	5.53 (13.586)	11.67 (19.967)	4.80 (12.627)	10.33 (18 745)	61.67 (51.756)	45.33 (42.346)
,, 0.5%	7.53 (15.911)	16.53 (23.939)	5.10 (13.028)	11.63 (19.922)	5.27 (13.264)	11.53 (19.832)	60.67 (51.161)	49.00 (44.426)
Coconut oil 1%	1.90 (7.886)	6.27 (14.491)	1.70 (7.476)	6.23 (14.456)	1.50 (7.017)	3.07 (10.084)	55.00 (47.875)	39.00 (38.645)
,, 0.5%	4.73 (12.558)	7.57 (15.963)	3.13 (10.168)	7.30 (15.668)	2.00 (8.103)	4.67 (12.467)	58.33 (49.799)	38.00 (38.043)
Gingelley oil 1%	4.43 (12.150)	12.90 (21.048)	4.60 (12.381)	12.27 (20.499)	2.10 (8.321)	6.37 (14.614)	59.00 (50.181)	42.33 (40.586)
,, 0.5%	5.10 (13.035)	12.40 (20.623)	5.70 (13.810)	11.20 (19.551)	2.57 (9.208)	6.30 (14.503)	59.67 (50.581)	45.67 (42.512)
Groundnut oil 1%	4.53 (12.277)	12.47 (20.665)	4.40 (12.098)	9.53 (17.974)	3.07 (10.031)	5.87 (13.993)	53.00 (46.721)	44.00 (41.517)
,, 0.5%	5.90 (14.055)	12.50 (20.669)	5.13 (13.036)	10.07 (18.486)	4.40 (12.106)	8.20 (15.963)	53.00 (46.721)	43.33 (41.149)
Rubber seed cake 1%	5.70 (13.810)	14.93 (22.729)	4.30 (11.943)	12.57 (20.759)	4.23 (11.872)	10.87 (19.246)	60.33 (50.973)	46.66 (43.088)
,, 0.5%	7.40 (15.781)	16.27 (23.781)	5.43 (13.464)	12.27 (20.488)	5.33 (13.346)	11.17 (19.504)	65.00 (53.730)	51.33 (45.764)
Rubber seed oil 1%	4.90 (12.780)	14.60 (22.463)	2.27 (8.604)	6.57 (14.832)	1.70 (7.489)	5.33 (13.343)	50.67 (45.382)	37.67 (37.853)
,, 0.5%	5.37 (13.375)	14.57 (22.431)	4.07 (11.632)	6.60 (14.883)	1.87 (7.841)	6.73 (15.031)	58.00 (49.606)	39.67 (39.033)
Paddy husk charcoal 1%	4.07 (11.625)	13.23 (21.331)	4.53 (12.279)	12.90 (21.042)	3.13 (10.158)	8.33 (16.736)	60.67 (51.164)	52.33 (46.339)
,, 0.5%	4.50 (12.243)	14.47 (22.354)	5.00 (22.919)	12.47 (20.668)	3.07 (10.069)	12.33 (20.555)	61.33 (51.161)	51.00 (45.573)
Control	8.50 (16.942)	17.07 (24.398)	6.20 (14.413)	13.63 (21.661)	6.40 (14.631)	13.43 (21.495)	71.00 (57 437)	55.67 (47.684)
C D	1.066	1.011	1.225	1.074	1.135	1.351	2.696	3.489

Data significant at 1% level. Figures within parentheses are angular transformed values.

percentages of infested grains in various treatments were calculated. For assessing the germination of grains mixed with different materials and stored, lots of hundred seeds were drawn from each replication and kept in petri dishes over a wet filter paper. The number of germinated grains were counted up to one week and the percentages of germination were calculated.

RESULTS AND DISCUSSION

The mean percentage of infestation and the mean germination of paddy grains mixed with various antifeedants or deterrents are presented in Table 1. Neem extract 1% and 0.5% and coconut oil 1% gave good protection to the grains from *R. dominica* up to six months during storage. Neem oil applied at 1% concentration gave relatively good protection and was on par with neem extract 0.5% during the third month. The relative efficacy of neem extract, neem seed kernel powder and neem leaves against *R. dominica* was reported by earlier workers also (JOTWANI & SIRCAR, 1965; PRADHAN & JOTWANI, 1968; JILANI & MALIK, 1973; SAVITHRI & SUBHA RAO, 1976, CHELLAPPA & CHELLAIAH, 1976). Rubber seed oil 1% and coconut oil 0.5% were found to be effective during the first month, but came low in rank subsequently. All other treatments were ineffective in protecting the grains from infestation by the borer.

Neem extract 1% was found to be the best among the treatments in protecting the grains from *S. cerealella* and neem extract at 0.5% also occupied relatively top rank. TEOTIA & TIWARI (1971), ABRAHAM *et al.*, (1972) and SAVITHRI & SUBHA RAO (1976) had reported the efficacy of powdered drupes and leaves of neem and neem seed kernel powder against *S. cerealella*. Neem oil 1% was on par with coconut oil 1% and neem extract 0.5% during the third and sixth month. All other treatments were found to be ineffective.

Neem extract 1% and coconut oil 1% gave best protection to the grains stored under godown conditions. Neem oil 1% and 0.5% occupied top ranks and were on par with coconut oil 1% up to the end of third month. All other treatments were ineffective.

The germination of the seeds mixed with neem extract 1% and 0.5% was not impaired even at the end of six months and was found to be on par with that of the control. Neem oil at both dosages adversely affected germination after the third month of storage and for the different concentrations of coconut oil, rubber seed oil and ground nut oil, germination percentage was very low from the beginning.

Considering the relative cost, effect on germination and effectiveness in protecting grains, neem extract at 0.5% can be considered as the best treatment for protecting stored paddy from insect infestation.

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EFFICACY OF DIFFERENT FORMULATIONS OF SOME INSECTICIDES AGAINST SORGHUM SHOOTFLY

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Seven insecticides were tried by different application methods in *kharif* season of 1980 against sorghum shootfly, *Atherigona soccata Rond* Out of these, treatment with carbofuran SP seed treatment and isofenphos granules were more or less equal in respect of control of shootfly as well as yield of sorghum. Other chemicals were not effective for the control of this pest. Nine insecticides were tried on three *rabi* cultivars *(CSH 8R, SPV-86* and *M 35-1)* in the *rabi* season of 1980-81 for the control of sorghum shootfly. Treatment with monocrotophos EC and methyl bromophos EC seed soaking and m. bromophos WP seed treatment adversely affected the germination in all cultivars. So also bendiocarb WP seed treatment and chlorpyriphos EC seed soaking reduced the germination considerably. In the remaining treatments carbofuran SP, carbofuran G and isofenphos G were quite promising and reduced the incidence of shootfly significantly without hampering seed germination. These treatments also produced significantly higher grain and fodder yields than other Insecticides and control (untreated).

(*Key words*: shootfly *Atherigona soccata*, control, insecticides)

INTRODUCTION

Carbofuran seed treatment has been proved to be the most easy, practical, effective and economic chemical method for the control of sorghum shootfly *Atherigona soccata* Rond. as compared to any other insecticide and insecticidal application method (JOTWANI & SUKHANI, 1968, 1971; JOTWANI *et al.*, 1972; JOTWANI & YOUNG, 1972; AMITNATH, 1972; KULKARNI *et al.*, 1973; SEPSAWADI *et al.*, 1974; JAGTAP, *et al*, 1974; PATIL, 1974). However, this chemical is more hazardous and the treatment has to be done under strict technical supervision, which limits its use on large scale. In order to still minimise the cost of chemical method for shootfly control, it is necessary to seek other methods, chemicals, formulations etc. Therefore, a comparative study was undertaken on new seed dressers and seed soaking in EC formulations along with carbofuran seed treatment. New granular forms were also included in the study.

MATERIALS AND METHODS

Insecticide soaked seed was planted in the field experiment using the hybrid *CSH-5*. The insecticides and rates were chlorpyriphos 20 EC, monocrotophos 40 EC and phosalone 35 EC, @ 4 ml/kg of seed. Seeds were soaked in the insecticide solution for overnight and the ratio of water to seed was 1:2 v/w. In addition to this, seed treatment with carbofuran 50 SP 5% w/w, bendiocarb WP 1.5 g/100 g of seed, methyl bromophos WP 2g/100 g of seed and isofenphos granules 2g/m row were also taken. Seeds were sown on 25-7-80 in a plot size of 4.5 × 3m, with a spacing of 45 × 15 cm, replicated three times.

Second experiment was conducted in *rabi* and seeds were sown on 27-9-80 in a plot size of 4.5 × 3 m with a spacing of 45 × 15 cm. Insecticide soaked seed was planted in a field

experiment using *rabi* cultivars *viz.*, *CSH—8R*, *SPV—86*, and *M 35—1*. A factorial randomised design with two replications was adopted. Treatments were the same as mentioned in the above eperiment. However, in addition to these, methyl bromophos EC seed soaking and carbofuran 3G 1.5g/m row were also included.

Observations of number of eggs and dead hearts were recorded at 14th and 28th days after germination and average number of eggs/plant and percentage of dead hearts were worked out at 28th day after germination. Germination count was also taken in *rabi* experiment. Data of grain and fodder yield were also recorded.

RESULTS AND DISCUSSION

Results in respect of number of eggs/plant, percentage of dead hearts, grain and fodder yield of *kharif* experiment are presented in Table 1. It is observed from this table that, egg laying of shootfly was significantly reduced in isofenphos granule treatment than the rest of the insecticides, however, it was at par with carbofuran SP. The percentage of dead hearts due to shootfly was significantly lesser in carbofuran SP than others except isofenphos granules, where it was at par with each other. The treatment with monocrotophos also showed promising trend for reducing the incidence of this pest. The grain yield was significantly higher in isofenphos granules than the rest of the treatments except carbofuran. Isofenphos granules produced significantly more fodder yield than the rest of the treatments.

TABLE 1. Effect of different insecticides on the incidence of shootfly and yield (*kharif* 1980—81).

Treatments	Shootfly		Grain yield	Fodder yield
	Av No of eggs/plant	% DH	q/ha	q ha
Carbofuran SP 50% 5% w/w ai	0.43	26.85 (30.96)	28.30	46.05
Isofenphos 5 G 2g m row	0.41	36.18 (36.91)	29.19	67.78
Monocrotophos 40 EC @ 4 ml/kg of seed	0.82	60.08 (56.23)	18.30	35.93
Chlorpyriphos 20 EC @ 4 ml/kg of seed	0.98	79.85 (64.66)	12.15	33.71
Bendiocarb WP @ 1.5g/100g of seed	1.01	82.16 (66.64)	19.26	33.34
Phosalone 35 EC @ 4 ml kg of seed	1.02	82.25 (67.61)	11.04	33.46
M. bromophos W.P @ 2g/100g of seed	1.02	90.25 (72.12)	11.12	33.58
Untreated	0.97	92.17 (73.77)	10.30	45.43
S E ±	0.075	5.120	1.86	5.61
CD at 5%	0.225	15.530	5.62	17 00

D H = Dead hearts
Figures in parentheses are Arcsin Tranrformation.

TABLE 2. Effect of insecticides on the incidence of shootfly on *rabi* sorghum cultivars and germination of seed (*Rabi*, 1980—81)

Varieties / Insecticides	Percentage of germination				Percentage of dead hearts due to shootfly					Grain and fodder yield q/ha			
	CSH 8R	*SPV 86*	*M35-1*	Mean	*CSH-8R*	*SPV-86*	*M35-1*	Mean		*CSH-8R*	*SPV-86*	*M35-1*	Mean
Chlorpyriphos 20 EC @ 4 ml/kg of seed	92.00	91.00	54.50	79.17	6.09 (14.13)	3.25 (10.11)	3.72 (10.95)	4.35 (10.73)	G F	24.29 20.46	30.49 30.15	23.17 47.43	26.02 32.79
Monocrotophos 40 EC @ 4 ml/kg of seed	11.00	17.50	00.00	9.50	4.52 (8.78)	1.85 (5.54)	0.00 (0.00)	2.12 (4.77)	G F	6.91 7.11	12.20 18.63	0.00 0.00	6.37 8.58
Phosalone 35 EC @ 4 ml/kg of seed	95.50	95.00	90.00	93.50	14.18 (22.12)	2.30 (8.62)	6.49 (14.71)	7.65 (15.15)	G F	27.44 27.64	18.97 27.24	20.33 37.80	22.24 30.89
M. bromphos EC @ 4 ml/kg of seed	2.50	14.00	00.00	5.50	0.00 (0.00)	4.51 (8.78)	0.00 (0.00)	1.50 (2.92)	G F	0.00 0.68	5.42 7.66	0.00 0.00	1.80 2.78
Isofenphos 5 G 2 g/m row	93.50	92.00	94.00	93.16	11.14 (19.20)	3.47 (10.59)	4.56 (13.81)	6.39 (13.76)	G F	37.26 50.61	32.52 46.41	24.86 70.80	31.54 55.93
Carbofuran 3G 4 g/m row	93.50	96.50	91.00	93.66	13.66 (21.58)	0.66 (4.47)	3.53 (9.02)	6.61 (11.69)	G F	33.54 23.71	34.21 47.09	24.19 64.88	30.64 45.16
M. bromophos WP @ 2 g/100g of seed	6.50	6.00	0.00	4.16	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	G F	0.00 1.36	5.42 0.34	0.00 0.00	1.80 0.56
Bendiocarb WP @ 1.5 g/100g of seed	73.00	7.50	56.00	45.50	12.78 (21.91)	7.41 (15.60)	5.68 (13.81)	8.62 (17.10)	G F	25.07 18.68	25.41 27.98	18.97 41.26	23.14 29.28
Carbofuran 50 SP 5% w/w a i	71.00	90.50	97.00	86.16	7 18 (15.48)	3.22 (10.38)	2.19 (8.52)	4.19 (11.46)	G F	37.26 40.99	35.23 50.47	23.51 47.63	31.99 46.29
Control	93.00	89.00	96.00	92.83	34.45 (35.93)	22.45 (28.32)	16.15 (23.68)	24.35 (29.31)	G F	23.04 19.99	21.00 30.15	15.24 34.89	19.76 28.33
Mean	63.15	59.95	57.85		11.42 (15.91)	4.91 (10.24)	4.23 (9.22)		G F	21.49 21.12	22.09 28.62	15.03 34.43	

Figures in brackets are arscin values. G = grain yield, F = fodder yield

	I) Germination		II) Dead hearts		III)	
	S E ±	C D at 5%	S E ±	C D at 5%	S E ±	C D at 5%
Varieties	1.60	4.61	0.93	2.68	G 0.84 F 1.19	2.37 3.43
Insectscides	2.91	8.38	1.70	4.90	G 1.53 F 2.17	4.40 6.25
Varieties x Insecticides	5.05	14.54	2.94	N S	G 2.64 F 3.75	N S 10 95

The next promising treatments in respect of grain and fodder were monocrotophos and bendicarb seed soaking.

Results in respect of germination, percentage of dead hearts, grain and fodder yield of *rabi* experiment are presented in Table 2. It is seen from this table that monocrotophos EC, mythyl bromophos EC and M. bromophos WP drastically reduced the germination in all these three cultivars. Germination was reduced considerably in chlorpyriphos EC and bendiccarb WP. Significantly germination was reduced in *M 35-1* as compared to *CSH-8R*, however, it was at par with *SPV-86*. All insecticidal treatments (excluding monocrotophos EC, M. bromophos EC and M. bromophos WP, where plants were negligible) gave significantly better results in respect of reducing the incidence of shootfly and produced significantly lesser dead hearts as compared to control (untreated). Considering the germination of seed, carbofurans SP, isofenphos G carbofuran G and phosalone EC were more promising for the control of this pest than others and significantly superior over control (untreated. *M 35-1* was relatively less susceptible to this pest and showed significantly lesser dead hearts than *CSH-8R*, except *SPV-86*. Variety *SPV-86* produced significantly higher grain yield than *M 35-1*, however, it was at par with *CSH-8R*. Treatment with carbofuran SP gave significantly higher grain yield than the other treatments except isofenphos G and carbofuran G. Significantly more fodder yield was noticed in isofenphos G than other treatments. Next promising insecticide is carbofuran SP and it was at par with carbofuran G.

From the above results, it appeared that granular formulations are more effective than any other forms for the control of sorghum shootfly in all cultivars. Effectiveness of granular forms of carbofuran (AWALE, 1970; AMITNATH, 1972; JAGTAP *et al.*, 1974) and isofenphos (SUKHANI & JOTWANI, 1980; CHUNDURWAR *et al.*, 1979) are well documented. However use of granules is limited due to its high cost, time consuming, cumbersome application etc. New insecticides like bromophos and bendiocarb seed treatments were ineffective as compared to carbofuran seed treatment. Seed soaking in emulsifiable concentratinns is also ineffective and also affected germination considerably. However, in this situation of low shootfly incidence, phosalone seed soaking was somewhat encouraging. Therefore, considering the germination effect, control of shootfly, grain and fodder yield, medium cost and easy application, carbofuran SP seed treatment still stands topmost for the control of shootfly in sorghum whether in *kharif* or *rabi* seasons or on any cultivar. Hence at present its use is justifiable for the control of this pest.

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CHEMICAL CONTROL OF MANGO LEAF WEBBER *ORTHAGA EUADRUSALIS* WALKER

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The mango leaf webber, *Orthaga euadrusalis* is a new and serious defoliator on mango. Nine insecticides were evaluated to find a suitable chemical to control this pest. Carbaryl 0.2%, quinalphos 0.05% and monocrotophos 0.05% were found to be effective. Two sprays at 15 days interval in September is recommended.

(*Key words: Orthaga euadrusalis,* chemical control)

INTRODUCTION

The mango leaf webber, *Orthaga euadrusalis* was first observed as a serious pest on mango in 1977 in Masauli, Barabanki district, U. P. (TANDON & SRIVASTAVA, 1979). Later the pest was seen spreading to adjacent areas. The caterpillars loosely web several leaves of a shoot together and from within feed by defoliating. After feeding what remains are dry bits of leaves, web and excreta. When the whole tree is attacked, it gives a completely burnt look. The infestation range varied between 25 to 100% on trees. Some orchards showed 100% infestation. As the pest in a short time gained a major problem status, it necessitated evaluation for a suitable chemical to control it.

MATERIAL AND METHODS

Nine insecticides *viz.*, carbaryl 0.2%, monocrotophos 0.05%, quinalphos 0.05%, methyl parathion 0.05%, chlorpyriphos 0.04%, phenthoate 0.05%, diazinon 0.05% and formathion 0.05% were tried in two years of high infestation, i.e., 1978 and 1980. One treatment included control. The treatments were replicated thrice, with a tree forming an experimental unit per treatment per replication. Two sprays were given at 15 days interval in September. Pretreatment, and post treatment population counts after 3, 7 and 14 days after first spray and again 3, 7 and 14 days after second spray, were made. The data were subjected to analysis of variance. The experiment in both the years were conducted at Bhira (Kheri), U. P.

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RESULTS AND DISCUSSION

Pretreatment population in both the years showed no significance among the treatments, implying a uniform population level among the trees chosen for the experiment. The population ranged from 9.0 to 24.66 caterpillars per bunch in 1978 and from 1.0 to 17.66 in 1980.

Results after three days of first spray in 1978 showed that quinalphos gave the best result. This insecticide was the only one which showed cent per cent control 3 days after every spray. However, all insecticides except formothion were on par with quinalphos, 3 days after the first spray in 1978, at 0.05 probability level.

After seven days, carbaryl, monocrotophos and methyl parathion showed zero population, while quinalphos had an average of 0.33, which may be due to chance as later (14 days) it recorded zero population.

TABLE 1. Effect of spraying insecticides on *Orthaga euadrusalis*.

Chemicals	Average number of insects per bunch						
	Pretre-atment	I Spray			II Spray		
		3 days	7 days	14 days	3 days	7 days	14 days
				1978			
Carbaryl 0.2%	9.00	.33(1.14)	0 (1.0)	.33(1.14)	0 (1.0)	0 (1.0)	0 (1.0)
Monocrotophos 0.05%	10.33	.33(1.14)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)
Quinalphos 0.05%	15.66	0 (1.0)	.33(1.14)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)
Methyl parathion 0.05%	24.66	.66(1.27)	0 (1.0)	2.33(1.76)	0 (1.0)	0 (1.0)	0 (1.0)
Chlorpyriphos 0.04%	14.66	1.33(1.47)	.33(1.14)	1.0 (1.33)	0 (1.0)	0 (1.0)	0 (1.0)
Phenthoate 0.05%	20.00	2.33(1.73)	1.0 (1.38)	1.33(1.49)	0 (1.0)	0 (1.0)	0 (1.0)
Fenitrothion 0.05%	19.00	2.66(1.82)	1.33(1.80)	2.66(1.82)	0 (1.0)	.33(1.14)	.66(1.27)
Diazinon 0.05%	16.00	3.00(1.85)	2.33(2.13)	2.66(1.88)	.33(1.14)	.33(1.14)	.66(1.27)
Formothion 0.05%	11.00	4.33(2.28)	8.33(3.01)	3.66(2.10)	2.33(1.42)	3.33(2.04)	3.66(2.15)
Control	22.00	14.66(3.93)	17.66(4.28)	9.33(3.17)	5.66(2.57)	7.66(2.94)	7.33(2.8)
C D 5%	N S	1.07	0.80	0.88	0.38	0.27	0.25
C D 1%		1.47	1.10	1.21	0.53	0.37	0.34
				1980			
Carbaryl 0.2%	16.33	1.33(1.41)	1.0 (1.38)	0 (1.0)	0 (1.0)	0 (1.0)	.33(1.14)
Monocrotophos 0.05%	17.66	0 (1.0)	.33(1.14)	4.66(2.36)	1.66(1.48)	2.33(1.61)	.33(1.14)
Quinalphos 0.05%	7.13	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	.66(1.27)
Methyl parathion 0.05%	16.0	2.33(1.61)	.33(1.14)	2.66(1.79)	0 (1.0)	1.0 (1.33)	1.33(1.24)
Chlorpyriphos 0.04%	8.0	.66(1.27)	1.0 (1.38)	2.66(1.79)	2.0 (1.55)	8.66(2.79)	1.0 (1.38)
Phenthoate 0.05%	12.33	9.33(2.92)	1.33(1.41)	5.66(2.52)	10.0 (3.20)	1.33(1.47)	2.33(1.32)
Fenitrothion 0.05%	16.33	4.0 (2.43)	0 (1.0)	2.0 (1.62)	.66(1.24)	3.0 (1.85)	2.0 (1.71)
Diazinon 0.05%	1.0	0 (1.0)	1.33(1.41)	.66(1.27)	.33(1.13)	2.33(1.61)	2.33(1.73)
Formothion 0.05%	9.0	7.33(2.85)	4.66(2.22)	2.0 (1.71)	7 0 (2.82)	5.33(2.33)	2.66(2.16)
Control	14.3	7.66(2,91)	5.0 (2.43)	15.33(4.33)	19.0 (4.31)	26.66(5.12)	13.0 (3.73)
C D 5%	N S	1.81	0.82	0.97	1.30	1.74	0.18
C D 1%		2.56	1.12	1.32	1.78	2.39	0.24

But all these four chemicals were on par at CD 5%. Formothion showed an increase in population.

By 14 days monocrotophos, carbaryl and quinalphos recorded 100% control with a population level of zero, and proved to be among the best treatments, with sustained efficacy. Carbaryl which has relatively lower residue, had equal efficacy. All other insecticides showed a resurgence of the webber with increased population level, while the control, though with a much higher population, showed a declining trend.

Formothion, however, showed signs of control with approximately 55% reduction in the population from 7 to 14 days. probably formothion has a delayed action. Subsequently also, in other data, formothion shows a delayed and gradual action.

In the second spray, in 1978, carbaryl monocrotophos, quinalphos, methyl parathion, chlorpyriphos and phenthoate showed zero population upto 14 days proving to be highly effective when sprayed twice.

In 1980, 3 days after the first spray, only monocrotophos, quinalphos and diazinon were found superior to control. Diazinon had a low pretreatment population, and therefore showed initial control. Later it lost its efficacy, and 14 days after the second spray had a population greater than pretreatment population. In 1978, it proved to be a less effective insecticide.

After the first spray in 1980, carbaryl showed delayed, but effective action, then within 14 days it reduced the population to nil. Surprisingly, monocrotophos which showed an initial high control, lost its efficacy in 14 days, and was the least effective, following phenthoate, Quinalphos and carbaryl were the best with zero populations.

On the third day following the second spray, monocrotophos again failed to register effective control, as compared to carbaryl quinalphos and methylparathion, which gave the best results and were on par at both the probability levels. Phenthoate was the least effective and was on par with the control. However, subsequently, phenthoate proved better and showed parity with carbaryl and quinalphos. The delayed effect in formothion was again evident. Diazinon and fenitrothion showed an increase in population and again may not be reliable insecticides.

Fourteen days after the second spray carbaryl, monocrotophos, quinalphos, methyl parathion and phenthoate were equally effective statistically.

Insecticides like methyl parathion, phenthoate and chlorpyriphos proved their efficacy better after the second spray. When the population level is low, perhaps these can be recommended.

In general, in both the years, quinalphos and carbaryl gave the best control, reducing the population to almost nil within 14 days with one spray. A second spray, further, ensured good control. Monocrotophos though proved ineffective in 1980, showed promising after the second spray, and showed parity with carbaryl and quinalphos.

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STUDIES ON THE SUPERVISED CONTROL OF COTTON JASSID, (*AMRASCA BIGUTTULA BIGUTTULA* ISHIDA) IN THE PUNJAB

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Studies conducted at Faridkot revealed that *Amrasca biguttula biguttula* (Ishida) was a serious pest on American cotton *(G. hirsutum)* from end of July to the middle of August. Studies were made on the jassid population in relation to injury caused by this pest. *Bikaneri Narma* was most resistant followed by *RS 89, LSS* and *320 F*. Spraying done on the appearance of second grade injury symptoms (yellowing and curling of leaves in the upper canopy) proved very good for its control. Dimethoate 0.3 kg ai/ha proved best for this purpose and the affected leaves recovered within one week of spraying. The second grade injury symptoms first appeared in the end of July in *LSS, 320 F* and *RS 89* and in the second week of August in *Bikaneri Narma*. Only one spray was necessary on basis of such supervised control against four sprays done as per the fixed schedule of fortnightly sprays from end of June to the middle of August.

(Key words: supervissd control, cotton jassid, *Amrasca biguttula biguttula)*

INTRODUCTION

Among the sucking pests of cotton, the cotton jassid *viz.*, *Amrasca biguttula biguttula* (Ishida), is the most serious. In the Punjab 4 sprays at fortnightly interval from end of June have been recommended against this pest from time to time (SINGH *et al.*, 1958; BINDRA, 1968; ATWAL & SINGH, 1969). Since incidence of this pest varies in time and space, treatments done according to the calendar-based spray schedules are unnecessary in many situations and add to the pesticide load of the environment without any usefulness. The present studies were undertaken to devise a supervised control of this pest so that insecticides are used only when they are really necessary.

MATERIALS AND METHODS

These studies were conducted at Faridkot. Population dynamics of jassid was studied on *320 F*, a vareity of *Gossypium hirsutum*, sown on 2.6.1973 (replicated 4 times) and 28.4.1974 replicated 3 times). Nymphal population was recorded on 3 leaves/plant in the upper canopy at weekly interval from 10 randomly tagged plants in each repeat.

Jassid population and injury grades were studied on *hirsutum* varieties *LSS, 320 F, RS 89, Bikaneri Narma* and on *G. arboreum* vatiety *G 27*. These varieties were sown on 26.5.1974 in a randomised design with 4 replications having plot size of 9.90 × 9.60 m. Five plants per repeat were tagged at random and observations on the population of jassid nymphs were made daily along with jassid injury grades from July 20 to October 5, 1974. Grading was done using the following criteria: Grade I: Entire foliage free from crinkling and curling with no yellowing, bronzing (brick-red), browning and drying of leaves. Grade II: Yellowing and curling of leaves in the upper canopy of plants. Grade III: Crinkling, curling and yellowing of leaves almost all over the plant, marginal bronzing of a few lower leaves; plant growth noticeably hampered, Grade IV: Extreme curling, crinkling, yellowing bronzing and drying of leaves and progressive defoliation, plant growth greatly stunted. All the above experiments were done without using

any insecticide. However, a separate experiment was conducted wherein dimethoate (a systemic inseticide), malathion and DDT + BHC (contact insecticides) were compared for their effectiveness for the control of this pest when applied at the appearance of the symptoms of II grade jassid injury. This experiment was done on *PS 10* variety of American cotton which is highly susceptible to jassid and some of the recommended systemic and contact insecticides were used. It was a randomised block design experiment having 5 replications and 2 × 2 m plots. Compression sprayer was used for spraying and hessian cloth screens were used to check drift. Three plants per repeat were tagged at random and jassid population and injury grades were recorded one hour before spraying and one week after spraying.

RESULTS AND DISCUSSION

Population dynamics: The data presented in Table 1 revealed that during 1973 the jassid population was quite high in the end of July and it increased significantly during the first week of August. Population remained very high up to the middle of August and quite high up to September 12, and declined rapidly thereafter. During 1974, however, jassid population remained very high until the end of August and high up to September 19.

TABE 1. Population of jassid nymphs on *320 F* variety of American cotton.

Date	Mean* population per 30 leaves	
	1973	1974
July 28	58(7.7)	NR
August 8	89(9.5)	171(13.1)
August 14	97(9.9)	NR
August 22	40(6.4)	150(12.3)
August 29	25(5.1)	101(10.1)
September 5	35(6.0)	47(6.9)
September 12	18(4.4)	55(7.5)
September 19	3(1.9)	17(4.2)
September 26	0(1.0)	4(2.3)
October 3	4(2.3)	2(1.8)
October 10	1(1.3)	2(1.8)
October 17	0(1.0)	23(2.1)
October 24	0(1.0)	13(3.7)
November 2	1(1.4)	17(4.2)
November 9	2(1.8)	NR
November 16	6(2.6)	NR
C D (p = 0.05)	(1.2)	(2.0)

Figures in parentheses are $\sqrt{n+1}$ transfomed values.
*mean of 4 replications; NR = not recorded.

Jassid population on different varieties: The minimum mean cumulative jassid population was found on *G. 27 arboreum* cotton. It was significantly lower than that on all the *hirsutum* varieties, among which *Bikaneri Narma* registered minimum jassid population. It had significantly lower population than *LSS* and *320 F*. Variety *RS 89* proved on a par with *Bikaneri Narma* (Table 3).

Leaf size varied in different varieties significantly. As such population per cm^2 leaf area was calculated. It was found that still the trend was the same as mentioned above, except that the difference between *LSS* and *320 F* was also significant in this case.

Resistance on the basis of the final average injury grade was found to be in the following decending order:—*G 27*, *Bikaneri Narma*, *LSS*, *RS 89* and *320 F*. *Bikaneri Narma* seemed to be more tolerant than *RS 89* because even though they had the same population per unit leaf area, the final grade was lower in the *Bikaneri Narma* than that in *RS 89*. Similarly, *LSS* seemed to be more tolerant than *320 F* and *RS 89* because it registered lower final injury grade than these varieties even though it had higher population per unit leaf area. Earlier AFZAL & GHANI (1953) had reported that *desi* varieties of cotton were resistant to jassid attack under Punjab conditions

TABLE 2. Jassid population on different varieties of cotton at Faridkot.

Vareity	*Mean cumulative nymphal population per 15 leaves from July 20 to Sept. 5 (48 days)	Area per leaf (cm^2)	Mean cumulative jassid population per cm^2 leaf area	Final average injury grade
Hirsutum				
LSS	2352(48.5)	75.4	2.0(1.42)	2.7
320 F	2362(48.6)	94.6	1.7(1.30)	3.0
RS 89	1513(38.9)	82.9	1.2(1.10)	2.8
Bikaneri Narma	1325(36.4)	71.2	1.2(1.10)	2.3
Arboreum				
G 27	159(12.6)	25.4	0.4(0.62)	1.0
C D (p = 0.05)	(10.7)	22.0	(0.05)	0.2

*Mean of 4 replications (3 leaves × 5 plants).
Figures in parentheses are $\sqrt{n}$ transformations.

TABLE 3. Jassid population in relation to development of II injury grade in different varieties.

Variety	Date when 50% or more plants showed the injury grade	% plants showing the injury grade	Average no. of jassid nymphs/ leaf	Average no. of feeding days taken	Mean jassid-feeding days per leaf	Mean jassid-feeding days per 100 cm^2
LSS	31.7.74	65	4.9±1.2	12.6±2.9	75.6	100.3
320 F	31.7.74	80	6.0±1.4	10.8±2.5	52.9	55.9
RS 89	31.7.74	55	5.3±1.3	14.4±3.5	76.3	92.0
Bikaneri Narma	10.8.74	74	7.0±1.4	22.7±5.3	158.9	223.2
G 27	Did not appear	—	4.1±3.0 on 31.7.74		—	—

Jassid population in relation to plant injury: Appearance of insect injury symptoms would depend upon the pest population, the period of its feeding and tolerance of a particular variety. Jassid-feeding-days required to produce a II grade injury in a given variety were calculated by multiplying the mean population with the number of days after which the injury grades appear (Table 3). It was found that *G 27* variety of *arboreum* cotton was the most resistant because no injury symptoms appeared in its plants. Among the *hirsutum* varieties, *Bikaneri Narma* was the most resistant because more jassid population feeding for more number of days was required to produce the II grade injury in it than in the other varieties. In addition, IV grade injury symptoms did not appear in this variety.

Further, *320 F* seemed to be more susceptible than *LSS* and *RS 89* in which

TABLE 4. Comparative efficacy of some insecticides sprayed against cotton jassid when leaves showed II grade injury on *hirsutum* variety *RS 10.*

Treatment	Population per 9 leaves			Leaves (%) showing II grade injury	
	Before spray	*1 day after spray	1 week after spray	Before spray	1 week after spray
Dimethoate 0.3 kg	2.0	14.2(3.9)	0.4(1.2)	93.8(75.6)	17.6(24.8)
Malathion 0.75 kg	21.1	6.3(2.7)	38.7(6.3)	97.2(80.3)	67.7(55.4)
DDT 1 kg+BHC 1 kg	16.6	25.0(5.1)	53.8(7.4)	84.5(66.8)	86.7(68.6)
CD (p = 0.05)	NS	(1.4)	(0.4)	(8.4)	(11.4)

* there was heavy rain one day after spraying.

these symptoms appeared after approximately the some number of jassid-feeding-days.

Supervised control: Data on the effect of spraying done on the plants showing II grade injury are given in Table 4. It was found that 76.2 per cent of the affected leaves recovered in case of dimethoate as compared with 29.5 per cent recovery in malathion. However, there was no recovery in case of DDT+BHC spray. Poor recovery of leaves and lower reduction in pest population in case of malathion and DDT+BHC may have been due to the washing effect of rain on the spray deposits. Dimethoate was apparently absorbed in the plants before it rained and this kept the jassid population suppressed for one week which was the last date of observation.

Closer investigations revealed that recovery of II grade injury symptoms occurred only among the activity functioning leaves in the upper plant canopy. Affected leaves in the lower canopy (basal leaves) faild to respond to jassid control in this respett.

The following main points emerged from these studies:

1. Jassid population on cotton in the main cotton belt of the state was high only from last week of July to middle of August.

2. Maximum population was found during August. It may very in time and space depending upon a number of factors.

3 Spraying done when the plants showed II grade injury proved quite effective. Dimethoate proved better for jassid control and most of the affected plants recovered from the injury symptoms within a week.

4. *Bikaneri Narma* was resistant to the jassid and registered II grade injury during second week of August, against end of July in case of *LSS* and *320 F.*

5. Pesticide applications on the basis of II grade injury symptoms of jassid helped in reducing the number of sprays to one from the previously recommended 4 sprays (ANONYMOUS, 1973). The work conducted under the ICAR-funded "Operational Research Project on the Integrated control of cotton pests in the Punjab" from 1975—1981 has shown that adoption of supervised control programme resulted in 83 4 per cent reduction in the number of sprays against jassid. Cotton growers felt no difficulty in identifying jassid

injury symptoms. Hence supervised control of cotton jassid seems to be an ecologically, environmentaly and economically viable proposition and is recommended to date in Punjab for the control of this pest (ANONYMOUS, 1982).

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EVALUATION OF INSECTICIDES FOR THE CONTROL OF MANGO SHOOT GALL PSYLLA *APSYLLA CISTELLATA* (BUCKTON) (PSYLLIDAE : HOMOPTERA)

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Mango shoot gall, *Apsylla cistellata*, is a serious pest of mango in the terai belt of North India. Experiments conducted during 1979 and 1980, using a wide range of systemic and contact insecticides revealed that quinalphos .05% proved most effective in controlling the pest Other insecticides which were found effective were monocrotophos .05%, phosphomidon .75% + urea .1% and dimethoate .06%. The sprays were given thrice, beginning in the third week of August, at 15 day interval.

(*Key words: Apsylla cistellata*, insecticide evaluation, mango shoot gall psylla)

INTRODUCTION

Apsylla cistellata is a serious pest of mango *(Mangifera indica)*, causing galls on the leaf axils which result in the inhibition of inflorescence. Studies on its taxonomy, bionomics and control have been reported earlier (MATHUR, 1946, 1975; SINGH, 1964; PRASAD, 1957; GUPTA & HAQ, 1958; SINGH, 1975). This insect was found serious in the terai region of Northern India, causing serious damage to mango trees. These areas have been described by MATHUR (1975). As no satisfactory control measure has been worked out for the pest except for the work on systemic insecticides by SINGH *et al.* (1975) it was decided to evaluate a wide range of insecticides, to recommend suitable chemicals to the orchardists.

MATERIALS AND METHODS

Sixteen insecticide treatments including one control (see Table) in all were tried for the experiment. The selected orchard is in the terai belt of Northern India at Bhira (Kheri), U. P. and had a heavy infestation of maago shoot gall psylla. The treatments were replicated thrice. Observations were taken on the number of galls per ten shoots and percentage shoot infestation, based on ten branches taken randomly. The first spray was given in the third week of August, followed by two more sprays at 15 days interval. The experiment was conducted successively in 1979 and 1980. The data were subjected to analysis of variance.

RESULTS AND DISCUSSION

As indicated in the Table, in 1979, all insecticides, except phosphomidon, were significantly superior to the control, when number of galls per ten shoots were considered. Quinalphos proved to be the best with a minimum of 2.66 galls/ten shoots as compared to the control with 53.33 galls ten shoots. Interestingly, a combination of phosphomidon and urea, proved to be the second best, though phosphomidon by itself was not effective.

In 1980, however, phosphomidon and urea combination did not prove to be that effective but ranked fifth. Quinalphos

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TABLE 1. Comparative efficacy of insecticides against mango shoot gall psylla.

Sl. No.	Treatments	Average nubmer of galls per shoots		Average percentage shoot infestation by shoot gall psylla	
		1979	1980*	1979	1980*
1.	Monocrotophos 0.05%	10.66	14.00 (3.55)	46.66	13.33 (21.14)
2.	Monocrotophos 0.05%+Urea .1%	7.33	15.00 (3.47)	13.33	20.00 (25.36)
3.	Phosphomidon 0.075%	52.66	77.00 (8.07)	73.33	50.00 (45.29)
4.	Phosphomidon 0.075%+Urea .1%	4.66	21.60 (4.09)	20.00	16.66 (21.84)
5.	Dimethoate 0.06%	13.66	12.00 (2.69)	40.00	23.33) (28.28)
6.	Dimethoate 0.06%+Urea 0.1%	5.00	65.00 (8.66)	23.33	60.00 (50.94)
7.	Methyl demeton 0.05%	12.66	42.60 (6.35)	30.00	46.66 (43.08)
8.	Fenitrothion 0.05%	33.66	51.60 (6.23)	43.33	36.66 (33.84)
9.	Diazinon 0.04%	8.66	47.30 (6.42)	36.66	46.66 (43.78)
10.	Formothion 0.05%	29.33	69.30 (8.33)	70.00	53.33 (47.01)
11.	Quinalphos 0.05%	2.66	5.30 (2.32)	10.00	10.00 (16.91)
12.	Methyl parathion 0.05%	13.66	51.00 (7.20)	53.33	53.33) (46.92)
13.	Dichlorvos 0.05%	16.66	100.30 (9.97)	53.33	83.33 (73.41)
14.	Phosalone 0.05%	21.00	120.00 (10.99)	36.66	93.33) (81.05)
15.	Fenthion 0.05%	30.66	124.30 (11.16)	63.33	80.00 (71.40)
16.	Control	53.33	132.60 (11.56)	90.00	93.33 (87.81)
	C D 5%	12.41	3.30	5.16	28.21

* $\sqrt{n+1}$ transformation — data in bracket are transformed values.

Fig. 1. Mango shoot gall produced by *Apsylla cistellata.*

again ranked first with a gall number of 5.33 as compared to 133.66 in control, followed by dimethoate with 12.00 galls per ten shoots. Fenthion, fenitrothion and phosalone were some of the ineffective chemicals, as evident fro n the Table.

When percentage shoot infestation was considered, quinalphos proved to be superior with a mean of 10% infestation as compared to 90% in the control, in 1979. Monocrotophos and urea combination was on par with quinalphos at 5% CD, with a mean of 13.33%. Again, interestingly, the third best treatment was phosphomidon + urea, while phosphomidon alone was rated the least effective.

The trend for quinalphos in 1980 was the same, rating best among the 16 treatments, with a mean infestation of 16.91%, followed by monocrotophos and phosphomidon+urea with mean infestation of 21.14% and 21.84%, respectively.

In both the years quinalphos showed consistancy and superiority in effectively controlling the shoot gall psylla. No other treatments showed such consistancy. However, monocrotophos, dimethoate and phosphomidon+urea can also be recommended as these showed relatively effective control.

Phosphomidon alone did not prove to be effective but in combination with urea was effective This is perhaps suggestive of a probable synergistic action urea has with phosphomidon, and is worth further investigation. It may be mentioned that both urea in combination with monocrotophos and monocrotophos alone were effective, thus probably indicating the fact that urea may not have much of a role in enhancing the efficacy of monocrotophos. The same could be said for dimethoate also.

In our studies we also found dimethoate to be quite effective, at 0.06% as compared to 0.09% and 0.15% reported by SINGH *et al.* (1975).

Thus, after evaluating 12 insecticides and three of them in combination with urea, against mango shoot gall psylla (*Apsylla cistellata*) it was found that quinalphos .05% gave the most effective control. Other effective and worthy of recommendation were monocrotophos .05%, phosphomidon 0.075%+urea 0.1% and dimethoate 0.06%. Three sprays beginning from the third week of August at 15 days interval must be given. The pest is widely prevalent in the terai belts of northern India.

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STUDIES ON NEUROSECRETORY CELLS OF THE BRAIN OF *ACHOEA JANATA* LINN. (LEPIDOPTERA : NOCTUIDAE) DURING POSTEMBRYONIC DEVELOPMENT

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The neurosecretory cells (NSCS) of the brain of *Achoea janata* Linn. have been studied using paraldehyde fuchsin (PF) and performic acid resorcin (PARF) techniques during postembryonic development (i. e, from 1 st to 5th instar larvae, pupae and adults). Three principal types of cells viz., A, B, and C, have been observed. The A-cells have been further classified into subtypes, A-1, A-2, A-3, A-4; B cells into B-1, B-2 and there is only one type of C-cell. Four paired groups viz., medial, lateral, posterior and tritocerebral have been observed during the postembryonic development. Activity of the NSCs in the larva, pupa and adult has also been described.

(*Key words: Achoea janata*, neurosecretory cells, neurosecretory material, *Ricinus communis*)

INTRODUCTION

Notwithstanding the fact, that a large body of information is available on the NSCs of lepidopterous insects (see: NOVAK, 1975; ROWELL, 1976), only in a few papers (SINGH & ARIF, 1978; AWASTHI & SINGH, 1981 a, b) their numbers, types, groups and secretory activity have been described during the postembryonic development. Most authors have either studied mature larvae or pupae or adults. PANOV & KIND (1963), in 18 species of Lepidoptera and HINKS (1971) in 23 species examined the NSCs of the adult moths. Likewise, the work of WILLIAMS (1947, 1952) is confined to the diapausing pupae.

In this work, a detailed study of the NSCs of the brain (i.e, from 1st to 5th instar larvae, pupae and adults of both the sexes) has been done in *Achoea janata* Linn. during its postembryonic development.

MATERIALS AND METHODS

The larvae of *Achoea janata* were reared and maintained in the laboratory on fresh castor (*Ricinus communis*) leaves as described earlier (SINGH & AWASTHI, 1981). The brain of the 1st to 5th instar larvae, pupae (pre-, mid-and late stages) and adult males and females of appropriate ages was dissected out in insect Ringer (EPHRUSSI & BEADLE, 1936) and fixed in Bouin's fluid. Later, the brains were processed, sectioned 8—10 μm thick, and stained with paraldehyde fuchsin (PF—CAMERON & STEELE, 1959) and performic acid resorcin fuchsin (PARF—ITTYCHERIAH & MARKS, 1971) techniques.

OBSERVATIONS

Three main types of NSCs have been distinguished on the basis of staining properties in the brain of *Achoea viz.*, A, B and C-types; the A-cells stain purple or purple-red, B-cells orange green or green and C-cells bluish green or bright green. These staining properties remain unaltered during the postembryonic development. The A-and B-types have been further

TABEE 1. Number of NSCs in each brain lobe of *Achoea janata* L. during post embryonic development.

cell groups		Larval instar					Pupa			Adult	
		I	II	III	IV	V	Pre	Mid	Late	Male	Female
Medial	A—1	4	4	4	4	4	4	4	4	4	4
	A—2	—	4	4	4	4	4	4	4	4	4
	A—4	—	—	2	2	2	2	2	2	—	—
	B—1	—	3-5	5-6	6-8	7-8	7-8	8-12	13-16	18-22	18-21
	C	—	—	2	2	2	2	3-4	3-4	4	4
Lateral	A—2	—	5	5	5	5	5	5	5	5	5
	B—2	—	3-4	4-5	6-7	7-8	7-8	7-9	8-9	8-9	8-9
Posterior	A—3	—	2	2	2	2	2	2	2	2	2
	B—2	—	—	3-4	4-5	5-7	6-8	8-10	11-12	12-15	12-14
Tritocerebral	B—2	—	2	3-4	4-5	5-6	5-7	6-7	7-8	8-9	8-10

classified into A-1, A-2, A-3, A-4; B-1 and B-2 subtypes. There is no subtype of C-cells.

Four NSC-groups are recognisable-three viz., medial, lateral and posterior in the protocerebrum and one in the tritocerebrum. The medial group is composed of A-1, A-2, A-4, B-1, and C cells; the lateral A-2, B-2; the posterior A-3, B-2 and the tritocerebral group has only B-2 cells.

First instar larva

The brain of the first instar larvae has only medial groups of NSCs comprising 4,A-1 cells. Each cluster of medial NSCs is located extremely antero dorsal in position, on either side of the medial furrow.

Second instar larva

In the second instar, two types of NSCs viz., A and B types were clearly discernible in the various groups (Fig. 1); while the C-cells are indistinct. Medial group comprises of A-1, A-2, B-1; the lateral A-2, B-2; the posterior A-3 and the tritocerebral B-2 subtypes of cells (Table 1).

Third instar larva

All the 4-subtypes of A-cells (viz., A-1, A-2, A-3, A-4) were clearly observed in this instar. The A-4 subtypes consists of 2 cells in each medial group and can be distinguished from the rest of the A-cell subtypes by two main features-(1) having large neurosecretory granules in them and (2) being tear drop shaped in outline. In the lateral group, A-2 and in the posterior group A-3 cells were clearly observed.

The B-1 in the medial, B-2 in the lateral, posterior and tritocerebral groups were clearly observed, their number increases gradually (Table 1). The number and size of different types of cells are given in Tables 1 and 2a, respectively.

Fourth instar larva

In this instar, all the subtypes of cells are observed. The 4 A-1, 4 A-2, 2 A-4, 6-8 B-1, 2 C-cells in each medial

TABLE 2a. Average size of the NSCs (in μm) in the brain of *Achoea janata* Linn. during postembryonic development.

Groups			Larval Instars				
			I	II	III	IV	V
Medial	Cell body	A—1	13.75×12.5	17.5 ×15.75	22.65×20.00	27.33×24.00	35.00×29.5
	Nucleus		5.00	5.75	6.75	9.25	11.00
	Cell body	A—2	—	10.25×10.00	11.00×10.75	13.75×13.75	16.50×14.50
	Nucleus			4.00	5.00	5.50	5.75
	Cell body	A—4	—	—	16.4 ×10.5	20.00×15.00	29.0 ×15.5
	Nucleus				6.00	7.5	10.00
	Cell body	B—1	—	15.00×12.5	17.5 ×15.00	21.25×17.50	22.75×18.00
	Nucleus			6.25	8.5	8.5	9.00
	Cell body	C	—	—	16.25×12.5	18.5 ×16.55	20.25×15.25
	Nucleus				6.5	7.00	7.5
Lateral	Cell body	A—2	—	10.25×10.0	11.25×11.00	13.75×13.00	15.50×14.50
	Nucleus			3.8	4.5	5.00	5.25
	Cell body	B—2	—	11.25×10.0	12.00×11.75	17.75×14.25	16.5 ×14.00
	Nucleus			3.5	4.5	5.5	7.5
Posterior	Cell body	A—3	—	13.75×12.5	14.25×13.75	17.65×16.00	18.75×17.5
	Nucleus			4.5	5.00	5.85	6.25
	Cell body	B—2	—	—	14.5 ×13.00	17.00×16.75	18.25×15.00
	Nucleus				7.5	7.5	7.5
Tritocerebral	Cell body	B—2	—	11.25×11.25	15.00×13.75	16.75×15.00	18.25×15.75
	Nucleus			5.00	5.75	6.5	7.67

Longer and shorter diameter of the cell bodies and nuclei of each cell types in the brain of 10 insects from each developmental stage were measured and the averages recorded.

TABLE 2b. Average size of the NSCs (in μm) in the brain of *Achoea janata* Linn. during post-embryonic development.

Groups			Pupa			Adults	
			Pre	Mid	Late	Male	Female
Medial	Cell body Nucleus	A—1	33.00×25.75 11.25	35.00×26.5 10.75	32.00×24.5 10.00	45.00×37.00 13.25	41.5 ×36.00 13.75
	Cell body Nucleus	A—2	21.25×20.00 6.00	21.50×17.0 6.0	18.75×16.50 6.25	24.25×19.5 6.50	26.25×18.75 6.75
	Cell body Nucleus	A—4	23.75×13.00 8.50	29.0 ×18.0 10.00	24.00×15.35 9.5	—	—
	Cell body Nucleus	B—1	25.00×21.00 10.25	27.5 ×20.00 11.25	28.75×25.0 11.5	30.5 ×26.5 11.50	32.0 ×24.75 12.5
	Cell body Nucleus	C	21.25×16.00 7.5	24.25×16.00 7.5	25.5 ×19.5 8.25	27.00×21.00 10.00	27.5 ×23.50 8.50
Lateral	Cell body Nucleus	A—2	17.0 ×12.0 5.00	15.5 ×13.5 7.5	13.25×10.70 5.00	18.00×16.00 6.45	16.17×15.25 6.50
	Cell body Nucleus	B—2	18.67×17.00 7.5	20.00×17.5 7.5	22.5 ×19.00 8.00	24.00×20.25 9.5	23.5×18.75 9.00
Posterior	Cell body Nucleus	A—3	20.4 ×18.5 7.00	22.5 ×15.00 8.75	18.25×12.55 8.00	20.00×17.5 7.5	19.5 ×17.00 7.35
	Cell body Nucleus	B—2	19.45×18.00 8.00	21.75×19.75 9.5	25.00×23.75 10.5	25.00×19.00 11.00	28.9 ×24.75 12.00
Tritocerebral	Cell body Nucleus	B—2	19.00×18.5 8.00	22.5 ×22.5 9.65	23.75×21.5 10.75	27.00×21.5 12.50	28.50×28 12.00

Longer and shorter diameter of the cell bodies and nuclei of each cell types in the brain of 10 insects from each developmental stage were measured and the averages recorded.

group; 5 A-2, 6-7 B-2 in the lateral; 2 A-3, 4-5 B-2 cells in the tritocerebral groups were observed. An increase in the number of B-cells is further recorded (Table 1).

Fifth instar larva

A constant number of A-cell subtypes (A-1, A-2, A-3, A-4) have been found in different groups (Figs. 4, 17); the B-cell subtypes increase continuously (Table 1). The A, B and C-cells are haphazardly arranged. In a newly moulted larva, the cells have a small amount of NSM. On the second and third day, out of 4 A-1 cells, 2 A-1 cells (of a cerebral hemisphere) appear moderately filled (Fig. 19) while the remaining 2 contain a small amount of NSM, hence, the activity in all the 4 A-1 cells is not uniform. On the fifth and sixth day or prior to pupation, all the 4 A-1 cells in each lobe appear heavily loaded with NSM (Fig. 2).

Prepupa

When compared to the fifth instar larva, no change in the numbers, types and groups of NSCs in the prepupa is found. The subtypes of A, B and C cells are present in their respective groups (Figs. 7,11). The number of A-subtypes remains the same as in the previous instars, while a continuous increase in the number and size of B-cells in all the groups is recorded (Tables 1 and 2a, b).

Mid pupa

All the subtypes of NSCs are distinct in the mid pupa (Figs. 3, 9, 12, 14) and contain a copious amount of their specific secretions. An increase in the size of all the subtypes of cells i.e. A-1, A-2, A-4, B-1 of medial, A-2, B-2 of lateral, A-3, B-2 of posterior and B-2 of the tritocerebral at this stage has been recorded (Table 2b). An increase in the number of B cells was also noted (Table 1).

Late pupa

In the late pupa, as in the mid pupa the A-1, A-2, B-1 and C-cells are clearly seen (Fig. 18). A-type of cells decrease in size (Table 2b) contrary to A-cells, the B-cells increase in size. The types, numbers and groups remain the same as in the previous stage (Table 1).

Male adult

All the cell subtypes are quite distinct in the male moths (i.e. A-1, A-2, B-1 and C-cells in the medial) (Figs. 6, 13, 15, 16); A-2, B-2 in the lateral; A-3, B-2 in the posterior and B-2 in the tritocerebral groups (Table 1). The size of the cells increases in the adult moths, showing thereby resumed activity (Table 2b). The A-4 cells are not clearly discernible due to their inactivity.

Female adult

The various types and subtypes of cells occupy the same position in female as found in the male moths. The medial, lateral, posterior and tritocerebral groups are clearly observed (Figs. 5, 8, 10, 20). The arrangement, number and types of cells are identical in male and female moths (Tables 1 and 2b).

DISCUSSION

KOBAYASHI (1957) in *Bombyx mori* MCLEOD & BECK (1963) in *Ostrinia nubilalis*, HERMAN & GILBERT (1965) in *Hyalophora cecropia*, SINGH (1977) in *Diacrisia obliqua* and SINGH & AWASTHI (unpublished observations) in *Utetheisa pulchella* have observed two main types of cells viz., A and B cells. The A and B cells have been further classified into respective sub-types. RAINA & BELL (1978)

have classified the cells into 8 types, however, on the basis of staining properties, as they have described, all the 8 types come under either two i. e., A and B or three viz., A, B and C main types.

Three types of cells viz., A, B and C have been observed in the mature larvae and adults of *Bombyx mori* by NANDA & ROY (1973) and in *Amsacta* and *Philosamia* by AWASTHI & SINGH (1981 a, b) during the postembryonic development. In the brain of *Achoea*, three main types of cells viz. A, B and C types have been distinguished, which have been classified further into subtypes i. e. A cells into A-1, A-2, A-3, A-4; B cells into B-1, B-2. The C-cells are of only one type.

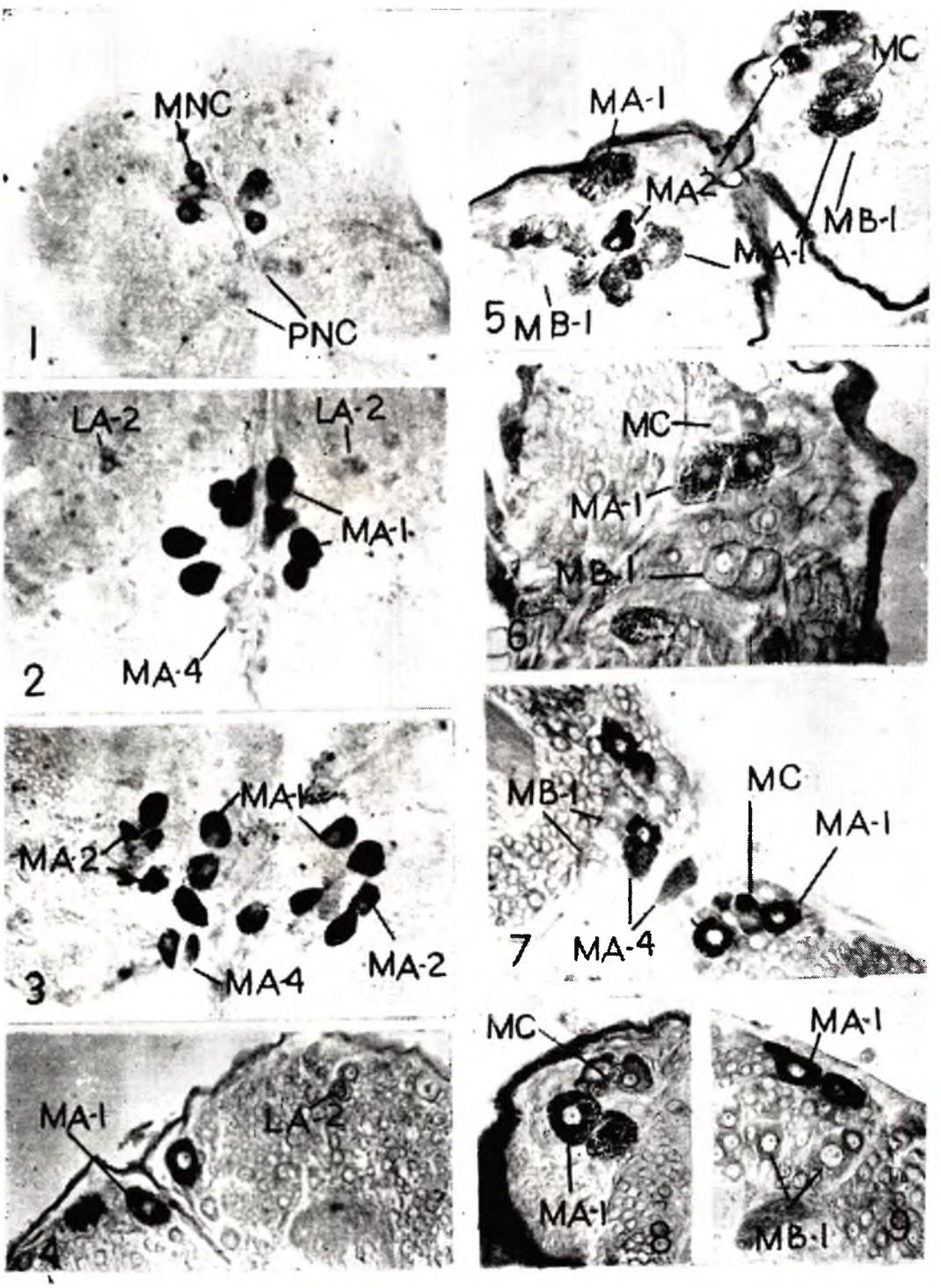
MITSUHASHI (1963) has reported four types of cells, viz.. A, B, C and D, in seven lepidopterous insects studied by him. The description of A, B, C and D cells given by him is very ambiguous. All the four types of cells designated by him, in fact, represent one main type, since they contain PF positive NSM in them, the others represent the subtypes of the one main type.

HINKS (1971) in 23 species of adult Lepidoptera has reported four types of cells; SINGH & ARIF (1978) in *Philosamia ricini* although reported four types but later in the same species AWASTHI & SINGH (1981 b) found only three main types of cells during the postembryonic development.

HINKS (1971) in 23 species of adult lepidopterans has observed two paired groups of cells viz., medial and lateral only. Three paired groups i. e. medial, lateral and posterior, have been observed in *Ostrinia nubilalis* (MCLEOD & BECK, 1963); *Hyalophora cecropia* (HERMAN & GILBERT, 1965; *Diacrisia obliqua* (SINGH, 1977); *Philosamia ricini* (SINGH & ARIF, 1978); *Pectinophora gossypiella* (RAINA & BELL, 1978; *Euxoa segetum* (KHATTER & MALLA, 1979) as well as in *Utetheisa pulchella* (unpublished observations). MITSUHASHI (1963) studied the NSCs in 7 lepidopteran insects and observed 4 paired-i. e. medial, lateral, posterior and optic groups of cells. AWASTHI & SINGH (1981 b) have also observed 4 paired groups viz. medial, lateral, posterior and tritocerebral, in *Philosamia ricini*. In *Manduca sexta*, NIJHOUT (1975) reported five paired groups of cells. In *Amsacta collaris*, six paired groups of cells viz., medial, lateral, posterior, tritocerebral, optic and ventral have been observed by AWASTHI & SINGH (1981 a).

EXPLANATION OF FIGURES

Fig. 1. W. M. of the brain of a second instar larva showing the medial (MNC) and posterior neurosecretory cells × 270; 2. W. M. of the brain of a 5 day old 5th instar larva showing heavily loaded medial A-1 (MA-1) and poorly filled A-4 (MA-4) cells, lateral A-2 cells (LA-2 are also seen) × 300; 3. W. M. of the brain of a mid pupa showing the medial A-1, A-2 and A-4 (MA-1, MA-2 and MA-4) cells filled with NSM × 275; 4. T. S. of brain of a 5th instar larva showing medial A-1 (MA-1) and lateral A-2 (LA-2) cells × 275; 5. F. S. of the brain of a female (before egg laying) showing the medial A-1, A-2, B-1 and C (MA-1, MA-2 MB-1, MC) cells with a fair amount of NSM × 275; 6. T. S. of the brain of a male moth showing A-1, B-1 and C cells × 275; 7. T. S. of the brain of a prepupa showing the medial A-1, A-4, B-1 and C (MA-1, MA-4, MB-1, MC) cells × 275; 8. T. S. of the brain of an adult female showing the medial A-1 and C (MA-1, MC) cells × 250; 9. T. S. of the brain of a mid pupa showing the heavily loaded medial A-1 and poorly filled B-1 (MA-1, MB-1) cells × 270.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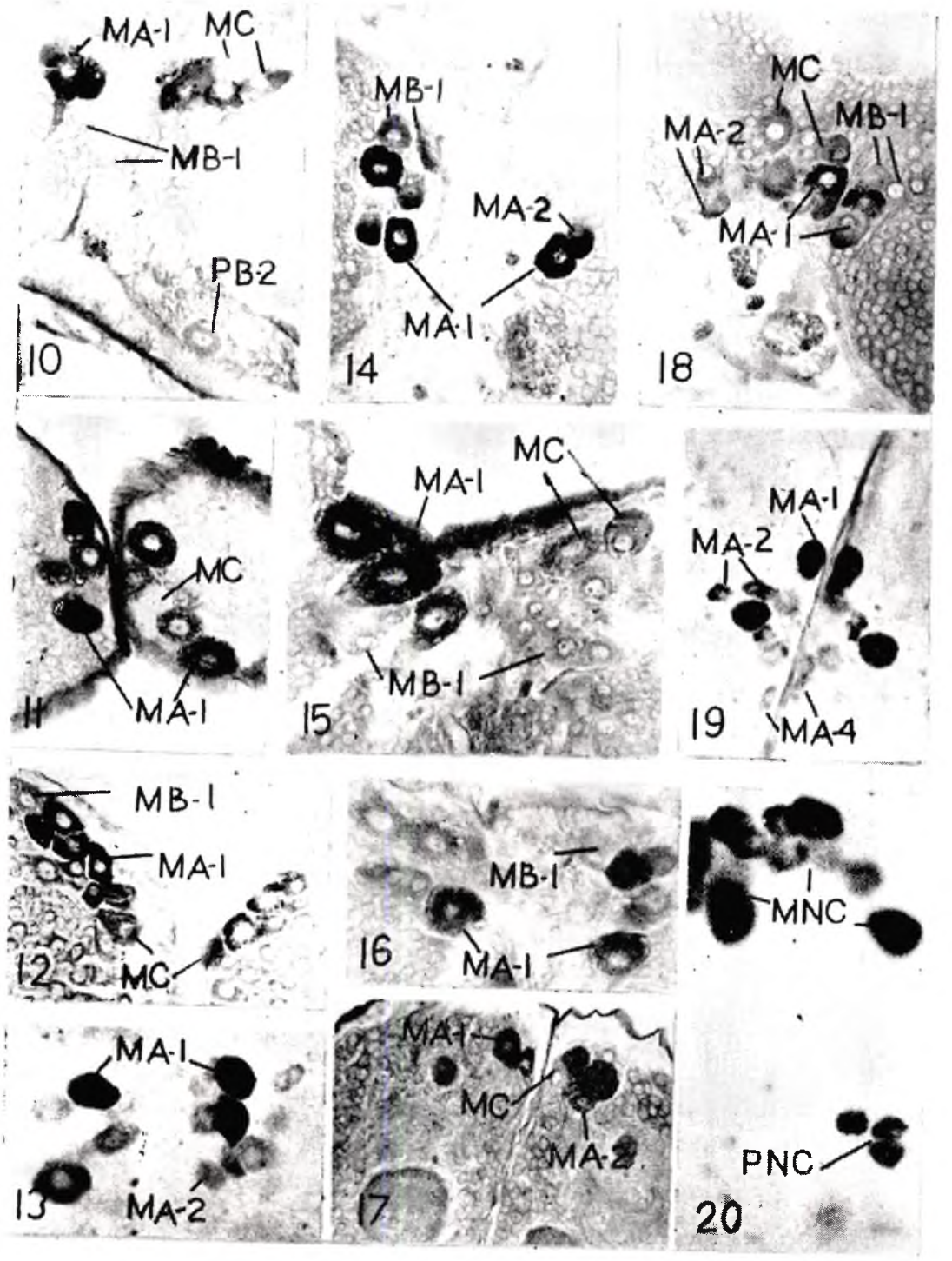
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19
MB-1
MA-1
MC
12
MB-1
MA-1
16
MNC
MA-1
MC
MA-2
17
PNC
20
MA-1
MA-2
13

In *Achoea janata,* four paired groups of cells viz., medial lateral, posterior and tritocerebral have been observed. The medial group is composed of A-2, A 2, A-4, B-1, C; the lateral group A-2, B-2; the posterior A-3, B-2 and the tritocerebral B-2 cells. The A-4 cells are tear drop-shaped, found 3rd instar onwards. Similar cells have also been found in *Utetheisa* (unpublished observations).

The posterior groups, have been regarded as a characteristic feature of the order Lepidoptera (HERMAN & GILBERT, 1965). Presence of the posterior groups of cells has been reported by MITSUHASHI & FUKAYA (1960), MCLEOD & BECK (1963), PANOV & KIND (1963), BASSURMANOVA & PANOV (1967), NANDA & ROY (1973), RAINA & BELL (1978), AWASTHI & SINGH (1981 a, b) and also in the present work on *Achoea.* KOBAYASHI (1957) BOUNHIOL *et al.* (1953) and GAWANDE *et al.* (1978) did not report the occurrence of the posterior group of NSCs in the brain of Lepidoptera examined by them.

GAWANDE *et al.* (1978) in *Heliothes armigera,* NIJHOUT (1975) in *Manduca sexta* and AWASTHI & SINGH (1981 a, b) in *Amsacta* and *Philosamia* as well as in the present work on *Achoea* have observed the tritocerebral NSCs.

AWASTHI & SINGH (1981 a, b) in *Amsacta* and *Philosamia* have observed 4 A-1 and 4 A-2 cells in each medial group. In *Utetheisa pulchella* (unpublished observations) and in the present work on *Achoea,* 4 A-1 and 4 A-2 and 2 A-4 cells have beeen clearly recorded in each brain lobe. Thus, there are 8—10 A-cells in each medial group which appears almost constant in Lepidoptera. MCLEOD & BECK (1963) in *Ostrinia nubilalis* as well as RAINA & BELL (1978) in *Pectinophora* have observed 9 A-cells in each medial group; HERMAN & GILBERT (1965) have recored 10 A cells in each medial group in *Hyalophora cecropia.* HINKS (1971) in 23 species of adult Lepidoptera has observed 8 to 10 A-cells and likewise PANOV & KIND (1963) found 8 to 9 A-cells in each medial groups of 8 species of Lepidopterous insects studied by them. Likewise, the number of A-cells, occurring in the posteroir group is also constant (i, e. there are 2 A-3 cells in each posterior group).

GAWANDE *et al.* (1978) in the fifth instar larva of *Heliothes armigera* have

Figs. 10. T. S. of the brain of an adult female showing the medial A-1, B-1 and C (MA-1 MB-1 and MC) cells. The posterior B-2 (PB-2) cells are also seen × 250; 11. T. S. of the brain of a prepupa showing medial A-1 and C cells × 300; 12. T. S. of the brain of a mid pupa showing the medial A-1, B-1 and C (MA-1, MB-1, MC) cells × 250; 13. W. M. of the brain of an adult male showing the medial A-1 cells with moderate NSM and A-2 cells with a small amount of NSM × 270; 14. T. S. of the brain of a mid pupa showing the medial A-1, A-2, B-1 (MA-1, MA-2, MB-1) cells × 270; 15. T. S. of brain of a male moth showing medial A-1, B-1 and C cells × 250; 16. F. S. of the brain of a male moth showing medial A-1 and B-1 (MA-1, MB-1) cells × 270; 17. T. S. of the brain of a 5th instar larva showing the medial A-1, A-2 and C (MA-1, MA-2, MC) cells × 250; 18. F. S. of the brain of a late pupa showing the medial A-1, A-2, B-1 and C (MA-1, MA-2, MB-1, MC) cells filled with their specific secretions × 250; 19. W. M. of the brain of a 4 day old 5th instar larva showing medial A-1, A-2, A-4 (MA-1, MA-2, MA-4) cells. The MA-1 cells are packed with NSM, MA2. contains a moderate amount of NSM and MA-4 cells a small amount of NSM × 300: 20. W. M. of the brain of an adult female showing medial and posterior cell (MNC, PNC) packed with NSM × 300.

found only nine medial NSCs which increase to twenty two (in prepupa and pupa). They have not classified NSCs into different types and have made no mention of the type(s) of cells or increase in number in medial, lateral and tritocerebral groups (i. e. which one out of A, B, C, etc. or all of them increase in number). It is well known that in Lepidoptera, the number of A, C and D cells remains almost constant and only the number of B cells increases (see HINKS, 1971; SINGH & ARIF, 1978; AWASTHI & SINGH, 1981 a, b). Further, no information is available on the posterior NSCs which have been found in all lepidopterous insects and have been regarded as the characteristic feature of the order. Hence the work of GAWANDE *et al.* (1978) cannot be compared to those of other researchers.

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STUDIES ON THE ERIOPHYID MITES (ACARINA : ERIOPHYOIDEA) OF INDIA. XII. DESCRIPTION OF THREE NEW SPECIES FROM BIHAR

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Three new species *viz.*, *Calepitrimerus massanjoris* sp. nov. (Eriophyoidae) infesting *Tectona* sp., *Disella tectona* sp. nov. infesting *Tectona* sp., and *Tegonotus bassius* sp. nov. infesting *Bassia* sp. are described from the state of Bihar, India. Relationships of these new species with the other known species under the respective genera, distributions, and host-mite relationships have also been discussed.

(Key words: Acarina, eriophyids, taxonomy, morphology, new species, India)

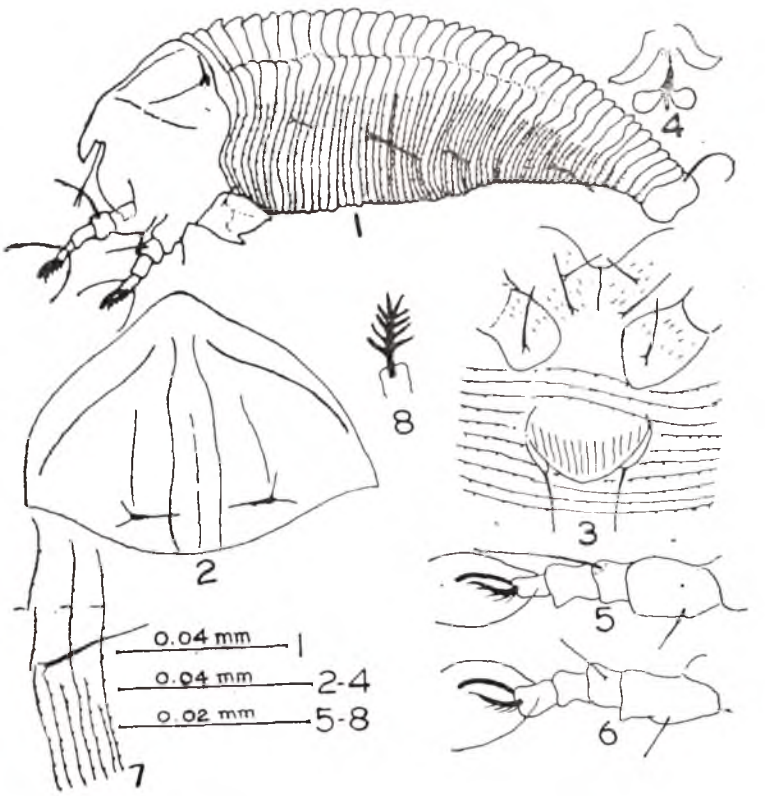
1. Calepitrimerus massanjoris sp. nov. (Figs. 1–8)

Female: Body 142-173[1] long; 48-50 wide; fusiform; pale white in colour. Rostrum 18.5 long, curved down; subapical seta 4.5 long; shield 34-38 long and 45 wide; subtriangular with a short anterior lobe projecting over rostral base; shield design simple; median line prominent from 0.45 portion to the rear shield margin; admedians arise at 0.2 portion anteriorly and run parallel upto rear shield margin; first submedian arises at the level of the admedians and run laterally towards the posterolateral angle of the shield; a longitudinal line arises at 0.4 portion of the shield and run upto the base of the dorsal tubercles; dorsal tubercles prominent 4.5 from rear shield margin, 20-23 apart; dorsal seta 7.5 long; centrad. Foreleg 27-30 long from trochanter base: femur 7-9 long with seta 6 long; patella 6 long; with seta 12 long; tibia 7.5 long; seta absent; tarsus 4.5 long with two tarsal seta, each 10-12 long; claw 7.5 long; featherclaw 5-rayed. Hindleg 22-24 long from trochanter base; femur 4-6 long; patellar seta 7.5 long; other characters as in foreleg. Coxae with coarse lines, centrally connate, sternal line prominent; first coxal seta 4.5 long, second coxal seta 12-15 long; third coxal seta 15-18 long. Abdomen with 36-42 tergites and 55-56 sternites; thanosome with a middorsal and two subdorsal ridges fading caudad with a dorsal trough at rear end; tergites and sternites well microtuberculated; lateral seta on sternite 8-10 and 6-8 long; first ventral seta on sternite 19-21 and 13-15 long; second ventral seta on sternite 32-36 and 4.5 long; third ventral seta on sternite 53-56 and 9-11 long; caudal seta 15 long; accessory seta absent. Female genitalia 12-14 long; 16-19 wide; coverflap with 14-16 scoring at lower half; genital seta 7-9 long.

Male: Unknown.

Holotype: ♀ on slide (No. 283/81/81),

[1]All measurements expressed in μm unless otherwise stated.



Caleptrimerus massanjoris sp. nov. *Female*: 1—lateral view of mite; 2—anterior dorsum of mite; 3—coxae and female genitalia; 4—internal female genitalia; 5—foreleg; 6—hindleg; 7—featherclaw; 8—side view of the skin structure.

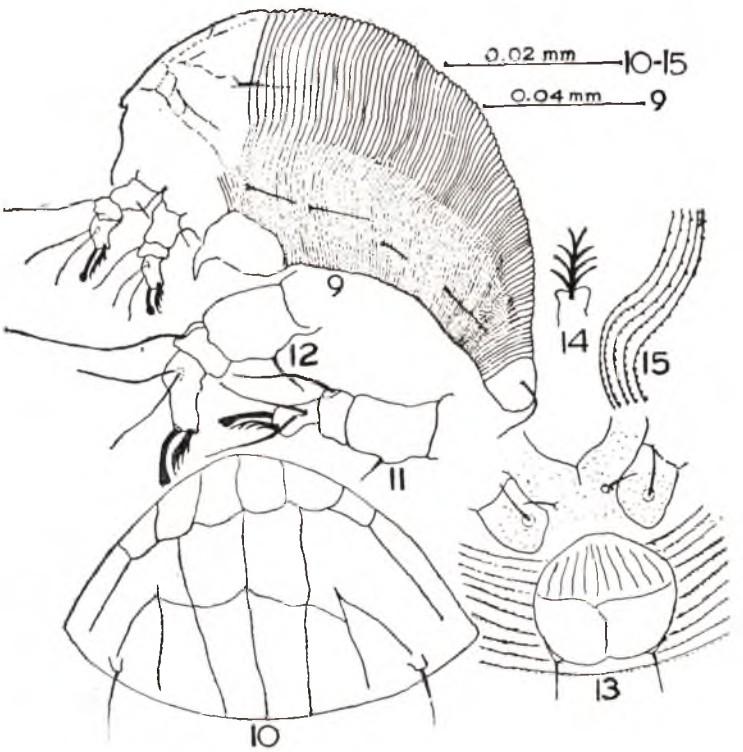
INDIA: BIHAR: Santhalpargana: Massanjore, collected on 12.i.1981 from *Tectona* sp. (Verbinaceae), coll. A. K. Das.

Paratype: Many ♀♀ on 5 slides (Nos. 204/84/81 to 208/84/81) collected on 12.ii.1981 from the same plant and same locality.

Distribution: India: Bihar.

The mites are vagrants on lower surface of leaves. This species are found on the same leaves along with *Disella tectona* sp. nov. Black spots is found due to the infestation.

Remark : *Calepitrimerus massanjoris* sp. nov. in having 5-rayed featherclaw comes close to *C. umbelliriae* Keifer (1939), *C. sibbaldiae* Roivainen (1950), *C. fagisylvatica* Keifer (1965), *C. mysorensis* Channabasavanna (1966), *C. cordae* Chakrabarti and Das (in press) and *C. antedesmae* Chakrabarti and Das (in press). Further, in having scoring on genital coverflap and lacking foretibial hair, the species also shows its affinity with *C. umbellinae* Keifer (1939) and *C. muesebecki* Keifer (1940). However, *C. massanjoris* sp. nov. remains distinct from all the above mentioned species in its shield design and other characters in details.



Disella tectona sp. nov. (Figs. 9—15). *Female*: 9—lateral view of mite; 10—anterior dorsum of mite; 11—hindleg; 12—foreleg; 13—coxae and female genitalia; 14—feather claw; 15—lateral view of skin structure.

2. Disella tectona sp. nov. (Figs. 9—15).

Female: Body 120—150 long; 64—75 wide; robust; white in colour. Rostrum large, 19—21 long; attenuate; subapical seta probably absent. Shield 33 long; 45 wide; smooth; subtriangular; anteriorly blunt without distinct anterior lob; eight large cells occupy the anterior margin; median line complete, arises from the junction of two median cells and touches the rear shield margin; admedians arise from the second pair of cells and touch the rear shield margin; first and second submedian arise from a common stalk at 0.5 portion of shield, a transverse line connecting the median admedian and first submedian present on 0.5 portion of the shield; dorsal tubercle little ahead of rear shield margin, 25—27 apart; dorsal seta directing rear, 10.5 long. Foreleg 25—26 long from trochanter base; femur 9 long; femoral seta 4.5 long, patella 4.5 long, patellar seta 18 long; tibia fused with tarsus to form tibio-tarsus, 7 5 long, with two seta, each 15 long; claw 6 long, knobbed; featherclaw 4-rayed. Hindleg 20 22 long from trochanter base; femur 6 long; patella 3 long, patellar seta 15 long; other characters as in foreleg. Fore-coxae flat, weakly divided with a short

sternal line, granulated; first coxal tubercles and seta absent; second coxal seta 7.5 long; third coxal seta 12 long. Abdomen abruptly tapering from 0.5 portion of thanosome to the caudal end; thanosome with 75—90 tergites and 80—100 sternites; sternites are well microtuberculated and tergites are less so; lateral seta on sternite 6—10 and 15—18 long; first ventral seta on sternite 20-25 and 19-20 long; second ventral seta on sternite 38-42 and 7.5 long; third ventral seta on sternite 60-65 and 13-15 long; caudal seta 17-21 long; accessory seta absent. Genitalia 15 long; 22 wide; coverflap with 8-10 longitudinal scorings on upper half; genital seta 4·6 long.

Male: Unknown.

Holotype: ♀ on slide (No. 209/82/81), INDIA: BIHAR: Santhalpargana: Massanjore, collected on 12.i.1981 from *Tectona* sp. (Verbenaceae), coll. A. K. Das.

Paratype: Many ♀♀ on 5 slides (Nos. 210/85/81/ to 214/85/81 collected on 12.ii.1981 from the same plant and same locality.

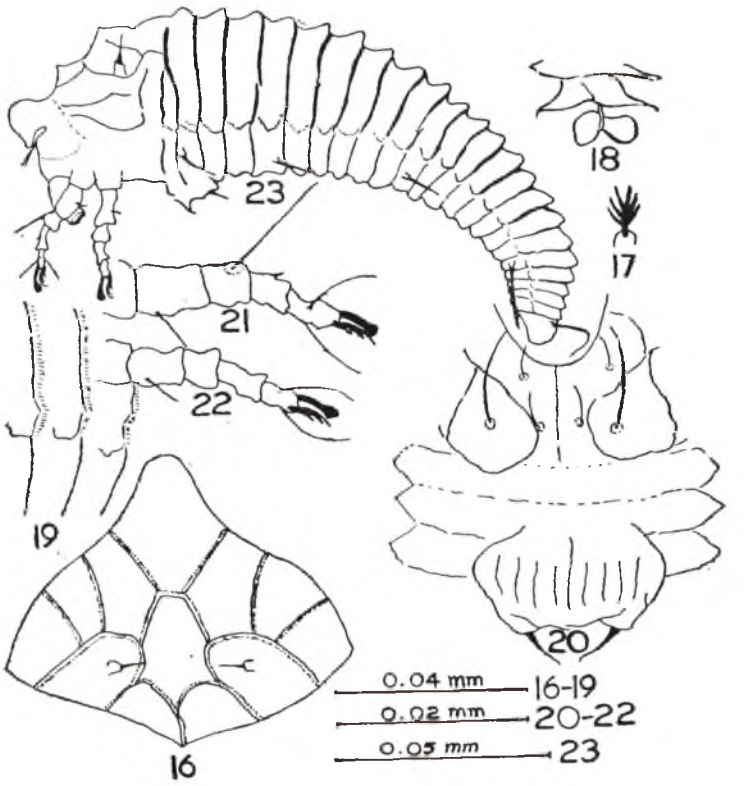
Distribution: India: Bihar.

Mites are leaf vagrants on ventral surface and were found along with *Calepitrimerus massanjoris* sp. nov. Due to infestation black spots were found.

Remark: The present species in having fused tibio-tarsus, first coxae weakly divided with a short sternal line, lacking first coxal tubercle and seta along with other characters, is a member of the genus *Disella* Keifer (1965). So far, two species are known under this genus *Disella tectona* sp. nov. in having 4-rayed featherclaw comes close to *Disella ilicis* Keifer (1965), *D. talisiae* Keifer (1969), but remains distinct from all the above mentioned species in the shield design in general and lateral shield cells and scoring on the upper half of the genital coverflap in particular.

3. Tegonotus bassius: sp. nov. (Figs. 16-23).

Female: Body 165-180 long; 45 wide; fursiform; pale brown in colour. Rostrum 19-23 long; bent down; antapical seta probably absent. Shield 42 long; 45 wide; subtriangular; apical lobe prominent and present over the rostral base as a thick body; shield design a complete network of prominent cells; median, admedian and submedians are not clearly distinguishable; a large apical cell, a central cell and three lateral cells on upper half and two lateral cells on lower half of the shield present; dorsal tubercles 7.5 ahead the rear shield margin, 15 apart; dorsal shield seta 7.5 long, directing centrad. Foreleg 30-35 long from trochanter base; femur 7.5 long with seta 6-8 long; patella 4.5 long with seta 10-12 long; tibia 7.5 long, seta very minute; tarsus 4.5 long with two tarsal seta, each 7-9 long; claw 4-6 long, knobbed; featherclaw 3 rayed. Hindleg 25-27 long from trochanter base; patellar seta missing; tibia 4 5 long, seta absent; tarsus 3 long; other characters as in foreleg. Coxae smooth, connate centrally, sternal line present; first coxal seta ahead of coxal approximation, 4.5 long; second coxal seta 4.5 long; third coxal seta 9 long Abdomen gradually tapering to caudad; subdorsal ridge present; tergites and sternites more or less equal in number ranging from 20-24; tergites non-microtuberculated but with rough edge; sternites are also non-microtuberculated; lateral seta present on sternite 1-2 and 7-9 long; first ventral seta on sternite 5-6 and 6-8 long; second ventral seta on sternite 11-12 and 6 long; third ventral seta on sternite 19-20 and 13-15 long: caudal seta 13-15 long; accessory



Tegonotui bassius sp. nov. (Eigs. 16—23). *Female*: 16—anterior dorsum of mite; 17—featherclaw; 18—internal female genitalia; 19—lateral view of skin structure; 20—coxae and female genitalia; 21—foreleg; 22—hindleg; 23—lateral view of mite.

seta absent. Genitalia 12 long, 18 wide, with 8-10 longitudinal scoring on the coverflap: genital seta 4.5 long.

Male: Unknown.

Holotype: ♀ on slide (No. 215/83/81), INDIA: BIHAR: Santhalpargana: Massanjore, collected on 13.i.1981 from *Bassia* sp. (Sapotaceae), coll. A. K. Das.

Paratype: Many ♀♀ on 5 slides (Nos. 216/86/81 to 220/86/81) collected on 12.ii.1981 from the same plant and same locality.

Distribution: India: Bihar.

Mites were found on ventral surface of leaves. No symptom of infestation was found.

Remark: *Tegonotus bassius* sp. nov. comes close to *T. acerivagrans* Keifer (1953) having 3-rayed featherclaw but differs from the latter in shield design.

All the type slides are deposited in the Biosystematics Research Unit, Department of Zoology, University of Kalyani.

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BIONOMICS OF *TRIOXYS (BINODOXYS) INDICUS* SUBBA RAO & SHARMA, AN APHIDIID PARASITOID OF *APHIS CRACCIVORA* KOCH. XII. COURTSHIP AND MATING BEHAVIOUR

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Either of the sexes of *Trioxs (Binodoxys) indicus* is ready to mate shortly after emergence. The period between emergence and mating varies from 5-15 min. The courtship behaviour involves the exchange of several sexual stimuli between the sexes. Multiple copulation never occurs in the female but is not uncommon in the males. The non-receptive female either moves away from the mate as soon as a male approaches her or discourages the male by characteristic antennal movement, with fluttering and bending down of the abdomen. Amputation of either antennae or wings of either sexes inhibited courting or mating. Olfaction of female pheromone plays a significant role in exciting the male; however, sight plays an important role in proper orientation of the male for coitus. Older mates do not actively court or mate. Shortly after emergence the female does not wait for the male for mating and start oviposition provided the hosts are available which results in considerable production of male progeny in fields.

(Key words: Trioxys (Binodoxys) indicus, Aphis craccivora, parasitoid, host courtship behaviour)

INTRODUCTION

MATTHEWS (1976) defined courtship as "any behaviours between conspecific individuals of opposite sex which facilitate mating". Mostly, the role of the conspecific male is the most impressive one; it is the female, however, who decides whether a copulation will ensue or not (ASSEM & POVEL, 1973). The courtship and mating behaviour might be acting as an ethological barrier between closely related sympatric species (ASSEM & POVEL, 1973; EVANS & MATTHEWS, 1976). A detailed courtship and mating behaviour is known only in some species of Pteromalidae (BARRASS, 1960a, b, 1961; MILLER & TSAO, 1974; ASSEM, 1970, 1974, 1975, 1976; ASSEM & POVEL, 1973; ASSEM & VISSER, 1976); however, in some detail, information is also available in certain members of Ichneumonidae and Braconidae (BOUSCH & BAERWALD, 1967; VINSON, 1972; OBARA & KITANO, 1974; WESELOH, 1977). Recently this has been reviewed by MATTHEWS (1976). Unfortunately, this behaviour in general, is little known among the aphidiids and only fragmentary and sketchy descriptions have been provided by SPENCER (1926), SEKHAR (1957), SCHLINGER & HALL (1960, 1961), MACKAUER (1969), HAMILTON (1974), SHALABY & RABASSE, (1979) and ASKARI & ALISHAH (1979). Earlier descriptions of the courtship and mating behaviour of *Trioxys (Binodoxys) indicus* are incomplete and superficial (SUBBA RAO & SHARMA, 1962). This behaviour in *T. indicus* is therefore described here in some detail.

MATERIAL AND METHODS

Nonmated male and virgin female of *T. indicus* of different age (from newly emerged to 5-day old) were drawn from the culture, released in a glass tube (15 × 1 cm) and observed visually with the help of a stereoscopic binocular for the courtship and mating behaviour. To observe the different factors involved in recognition of conspecifics culminating in successful mating, experiments with the following combinations of treated sexes were performed in adition to SUBBA RAO & SHARMA's experiments.

1. Antennectomised male with normal female and *vice versa*; 2. Wingectomised male with normal female and *vice versa*; 3. normal male with steam-killed female (steam killing was needed to wash off any adhering pheromone); 4. Normal male with hot needle-killed female (killed inside the tube), and 5. eye-coated (with black Indian Ink) male with normal female.

The following observations were recorded: a. pre-excitation period for male; b. total excitement period for male; c. pre-encounter period; d. total duration of courtship, and e. events of the behaviour.

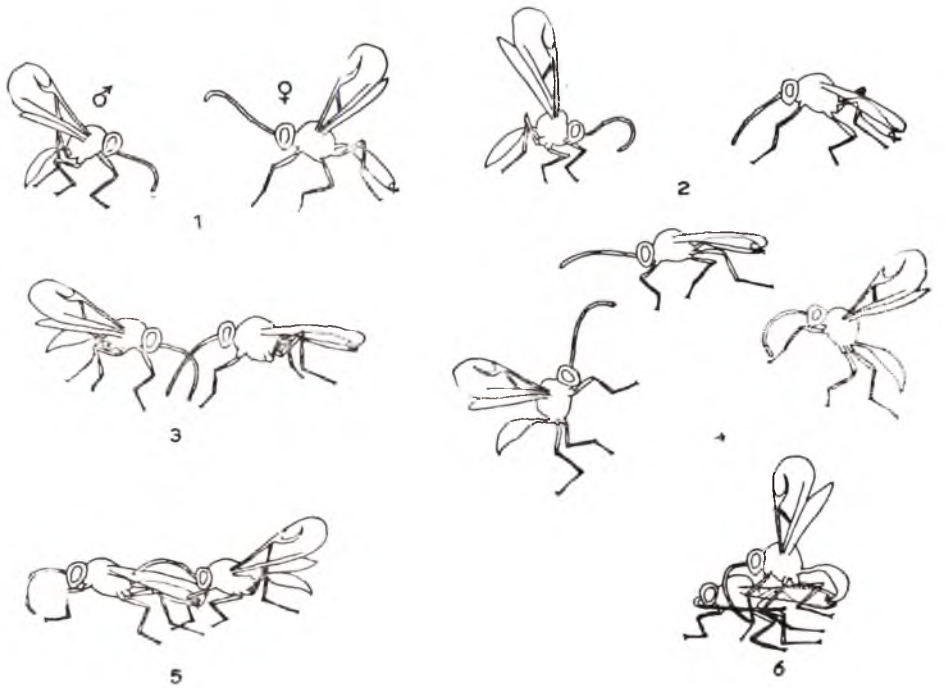
RESULTS AND DISCUSSION

It was found that either of the sexes of *T. indicus* is ready to mate shortly after emergence. This period (between emergence and mating) varies from 5-15 min., comprises two definite phases, *viz.*, (1) preparatory and (2) courtship resulting in mating. During preparatory phase the sexes dry and clean their wings and other organs. Then they walk about, stand-still frequently to preen or groom (cleaning of legs, mouth-parts, antennae, wings and abdomen) and feed if food (honey drop-30% honey solution) is available. This aspect of premating behaviour of *T. indicus* is much shorter than that reported for *Praon aguti* Smith and *Aphidius testaceipes* (Cresson) (less than an hour and a half) (SHEKHAR, 1957); 2 hr for *A. matricariae* (VEVAI, 1942) and 6·8 hr for *Aphidius* sp. (RAJA RAU, 1954). However, it is in agreement with *Praon palitans* and *T. utilis* (SCHLINGER & HALL, 1960, 1961). SHALABY & RABASSE (1979) described that the female of *A. matricariae* normally copulated soon after emergence, while males needed a period of about 2 hr in preparing themselves for mating. When male and female of the parasitoid under study were kept together in a chamber on the expiry of the preparatory phase (period excluding which is needed for their preparedness) (Fig. 1), the male gets excited, starts vibrating (fanning) his wings within a minute (53.6 ± 2.6 sec) as also reported for *P. palitans* and *T. utilis* (SCHLINGER & HALL, 1960, 1961) even without making any contact with female (Fig. 2). During excitement the male moves his antennae up and down-sometimes sidewise as well and vibrates his wings with a higher frequency holding them vertically above the thorax and butts his head up and down similar to other parasitoids (BARRASS, 1960a, b; SCHLINGER & HALL, 1960, 1961; ASSEM, 1970, 1974, 1975, 1976; ASSEM & VISSER, 1976). The role of female during this period is more or less passive. She either remains still preening her body parts, moving her antennae or walks slowly to and fro, sometimes taking a short flight. The highly excited male runs in the tube and performs the movement of wings and antennae as given above. The parasitoids clean their antennae and mouth-parts with fore legs, and wings and abdomen with hind legs. Mid and hind legs are cleaned by each other. Male after moving to and fro in the chamber, approaches the female, contacts her first by tapping or touching any part with his antennae (Fig. 3). As soon as the male touches the female, he gets further excited. Usually at this stage of courtship behaviour, the female moves from the place, and the male follows her diligently either by walking or by taking short flight but does

not trail her as reported by SCHLINGER & HALL (1960, 1961) either in *T. utilis* or in *T. palitans* This behaviour can provide, possibly, an important taxonomic character which can be well utilised in the identification of the various species of the genus *Trioxys* Haliday. The above sequence of events is likely to be repeated 4-7 times prior to mating. It was also observed that during the post-antennal contact phase (which occasionally was made) the male moves along her side keeping the antennae directed towards her body moving his abdomen up and down (from temporal to the rear of the body) in an anticlockwise direction (Fig. 4). During this phase of courtship behaviour the female parasitoid does not show any rapid antennal movement or wing vibration. Frequently, she rubs the distal part of the abdomen with the help of her hind legs. By such an act, possibly, she tries to disseminate her pheromonal secretion to give the male a more positive signal that she is practically ready for the coitus, and also to excite further and attract the male. With the culmination of this behaviour, the female stops her antennal movement, sits down by folding her legs and spreads her wings slightly horizontally resembling a platform and adopts a characteristic posture which facilitates the male to mount her back (Fig. 5). This characteristic posture adopted by the female acts as a sig al to indicate her receptivity. These signals are given by female only when she is highly excited and satisfied with her courting partner regarding his conspecificity. On the receipt of this signal from the female, the male, obviously sure about mating, secures his position on the back of the female. Sometimes, he attempts to rock on her from sides even without reaching the distal part of her abdomen and thereafter re-adjusts. During coitus, the male taps the head and thorax of the female with his antennae. Frequently, he brushes the antennae of female with his own. The movement of antennae is backwardly directed. With his legs the male grasps the female firmly in such a manner that his fore- and mid legs hold her mid- and hind legs respectively. The fore legs of the female and the hind legs of the male are free. Simultaneously the male places his hind legs against the posterior part of the female's abdomen for a footing on the substratum. Now the male curves his abdomen downwards and forwards so that his genitalia come into contact with that of the female (Fig. 6). During copulation the male vibrates his wings at highest frequency and brushes female s antennae with those of his own. During insemination the male keeps his vibrating wings directed posteriorly.

Courtship behaviour takes 210 ± 15 sec while mating lasts less than 20 sec (17 ± 2.9 sec). Courtship and mating periods vary from species to species. The former varies from 7-135 sec (VEVAI, 1942) to 200 sec (SHALABY & RABASSE, 1979) whereas the latter varies greatly from 14-135 sec in different aphidiid wasps, e g., 14-24 sec in *P. palitans* and *T. utilis* (SCHLINGER & HALL, 1960, 1961), 25-85 sec in *Diaeretiella rapae* Curtis (ATWAL *et al.* 1969 – however, ASKARI & ALISHAH (1979) reported it to be 50-130 sec), 30 sec in *Monoctonus pseudoplatani* Marshall (HAMILTON, 1974), 42 sec in *Aphidius matricariae* (SHALABY & RABASSE, 1979), 46 sec in *P. aguti* and 52 sec in *A. testaceipes* (SEKHAR, 1957).

The male shortly after mating exhibits postcopulatory behaviour. He regains the courtship posture for a repetition of



Figures 1—6: Courtship and mating behaviour of *Trioxys indicus* in sequence.

postcopulatory courtship. Usually this time the female again signals her receptivity (at the very start of the display) but as a rule, the male is unwilling for renewed mating and walks off as a discouraged partner. Second signal for mating by the female soon after the first act due to insfficient sperm transfer (COUSIN, 1933) has already been refuted long back by BARRASS in 1964 itself and now this behaviour is regarded as a requisition to switch off the receptive conditions (ASSEM & VISSER, 1976). After mating, the female becomes unreceptive for second mating for her whole life, as also reported earlier by SEKHAR (1957), SCHLINGER & HALL (1960, 1961), SHALABY & RABASSE (1979) in different aphidiid parasitoids. Thereafter, she was always found to discourage nonmated or mated male(s) of any age. The rejection of male is brought about by many ways, *viz*,, either she moves away as soon as male approaches to court, she jerks her head sidewise frequently in 'no' position and her abdomen bent downwards she moves away; or with antennal movement and fluttering wings. These activities are more or less akin to other members of the group but she was not observed to push male off her back by kicking with her hind legs as reported by SCHLINGER & HALL (1960, 1961). Sensing these activities of the female, the male quits and makes no further efforts to court or mate with her. Multiple copulation never occurs in the female but is not uncommon in males which may copulate with upto 5 females (with 12 females—SUBBA RAO & SHARMA, 1962). However, this number varies with the species. However, surprisingly, ATWAL *et al.* (1969) and HAMILTON (1974) have described the polyandry in *Diaeretiella rapae* and in *M. pseudoplatani* respectively.

TABLE 1. Sexual receptivity in male and female of *Trioxys indicus* in different experimental conditions (mean ± S D).

Different sets of mating pairs	Time taken by male for excitement (sec)	Duration of male excitement (sec)	Time taken by male in making 1st contact with female (sec)	Courtship period (sec)	Mating period (sec)
Normal male with normal female	54±2.6	390±126	165± 7.0	210±15.2	17±2.9
Normal male with antennectomised female	57±2.1	1260±68	180±10.2	—	—
Normal male with wingectomised female	60±3.7	1080±37	290±16.3	—	—
Normal male with normal female killed with hot needle	50±5.3	362±40	300±43.8	—	—
Wingectomised male with normal female	64±2.9	1200±32	307±19.9	—	—
Antennectomised male with normal female	—	—	—	—	—
Normal male with normal steam-killed female	—	—	550±174	—	—
Eye-coated male with normal female	56±5.7	980±157	430±275	—	—

The male was also observed to behave in a peculiar manner, *i. e.*, he tries to "copulate" with another male. Possibly this is due to high mating urge of the male.

Table 1 clearly shows that courtship and mating are possible only between normal and virgin females and males. Males mate more than once. Amputation of either antennae or wings of either sexes inhibited courting or mating. When antennectomised male and a virgin female or a normal male and steam-killed female were kept together even excitement of the male was not observed. However, when an antennectomised or wingectomised female was kept with a normal male, it was observed that the male gets sexually excited and remain in this condition for a longer duration and displays certain movements which are quite different from what is seen in a normal conditions, but does not mate. It was further observed that when a normal male was kept along with a hot needle-killed (inside the tube) normal female, the male got excited, though for a shorter duration but took more time in reaching the female.

Present investigations are in conformity with SUBBA RAO & SHARMA (1962) that the olfaction, and not the sight, plays a significant role in exciting the male sexually. The fact that antennectomised males do not even initiate sexual excitation confirms that these are essential for the perception of female pheromonal secretion which is necessary for exciting him. Sight, however, is important in the orientation of the male for the coitus.

The observation that steam-killed female in contrast to a normal one failed to elicit excitement in a normal male clearly shows the presence of some odorous chemicals in her (sex pheromone) which was completely washed off from her body during steaming and is further proved in case of hot needle-killed female, which does excite the male sexually, though for shorter duration. The excitation (for a shorter duration) of the male in the latter case possibly is due to the cessation of the pheromonal secretion (on account of the death of the female) and the longer time taken by him to approach the female possibly because he gets confused due to the homogenous diffused pheromone. The nature and source of the sex pheromone in *T. indicus* are yet to be investigated. However, in *D. rapae* the site of the sex pheromone is abdomen (ASKARI & ALISHAH, 1979); its exact location is not known.

The observations (Table 1) also indicate that the presence of antennae and wings are essential for courtship and successful mating as they are involved in the exchange of sexual stimuli during courtship behaviour.

Older mates (male and/or female) do not actively court or mate, possibly due to their physical disability or lesser production of sex pheromone. More than 5 day old male or female sparingly court or mate. It was also observed that shortly after emergence the females do not wait for mating but start oviposition provided the hosts are available. During this act when a male approaches her, in the beginning, she resists mating; of course, later on she does mate. This behaviour of the female results in a considerable production of male progeny in the fields (SINGH & SINHA, 1980).

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BRIEF COMMUNICATION

LEVELS OF PHOSPHATASES DURING PUPAL-ADULT TRANSFORMATION IN *SPODOPTERA MAURITIA* BOUISD. (LEPIDOPTERA : NOCTUIDAE)

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Acid- and alkaline phosphatase activities in the whole tissue extracts from pupae of *Spodoptera mauritia* during different days of pupal period have been investigated. Activity patterns of phosphatases show more or less a 'U' shaped curve. There is marked increase in the ativities of phosphatases before pupal-adult ecdysis.

(*Key words:* alkaline- and acid phosphatases, pupal- adult transformation, *Spodoptera mauritia*)

In holometabolous insects the transformation of larva to imago involves extensive histolysis of larval tissues and the corresponding degree of histogenesis of imaginal organs. Phosphatases are implicated in the histolysis of larval organs (LOCKSHIN, 1969) as well as remodelling of fat body cells (VERKUIL, 1978). Except for a few studies (GILBERT & HUDDLESTON, 1965; ROUSELL, 1971; SPATES & WRIGHT, 1975), our knowledge on the changes in the activities of these enzymes during pupal adult transformation is scanty. This paper is concerned with a study of the phosphatase activity throughout the pupal instar of *Spodoptera mauritia* (Lepidoptera : Noctuidae).

Specimens of *S. mauritia* were reared and maintained as described previously (NAIR, 1981). Imaginal moult took place 7 days after pupariation and so enzyme and protein assays were made from 0 day old (newly moulted) to 7 day old pupae. Five pupae of uniform size were selected, rinsed well in distilled water and dried. Each pupa was weighed in a single pan precision balance and homogenized in 2 ml of cold 10 mM β mercaptoethanol taken in a Potter-Elvehjem type homogenizer packed in crushed ice. The homogenate was centrifuged at 4°C in a refrigerated centrifuge (International Equip. Corp., U. S. A.) at 500 g for 10 min to remove gross cuticular debris. Aliquots of supernatant were used for enzyme and protein determinations. Quantitative estimations of phosphatases were based on the methods described in Boehringer Mannheim Test Hand Book (1971) using *p*-nitrophenyl phosphate as substrate. Protein was determined according to the method of LOWRY *et al.*, (1951). The optical densities were measured in Klett-Summerson photoelectric colorimeter. One unit of enzyme activity corresponds to the liberation of 1 μ mol *p*-nitrophenol per hour under experimental conditions. Specific activity is expressed as units/mg protein.

Alkaline and acid phosphatase activities show changes during different days of pupal-adult transformation. This is well documented whether the values are calculated per mg body weight (total activity) (Fig. 1) or per mg protein (specific activity)

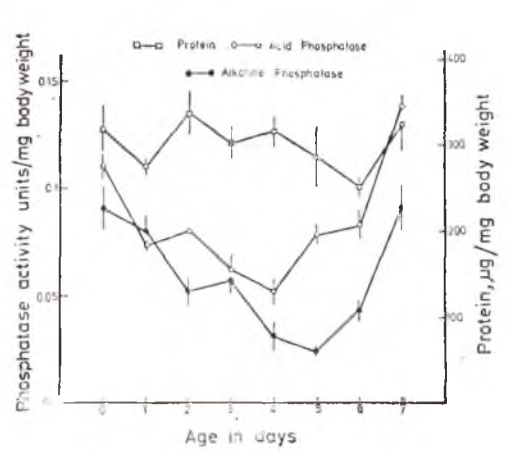

Fig. 1. Changes in protein, total activities of acid phosphatase and alkaline phosphatase during pupal-adult transformation of *S. mauritia*. Each point represents the mean of five replicate experiments ± SD. In this and succeeding figure vertical lines represent standard deviations.

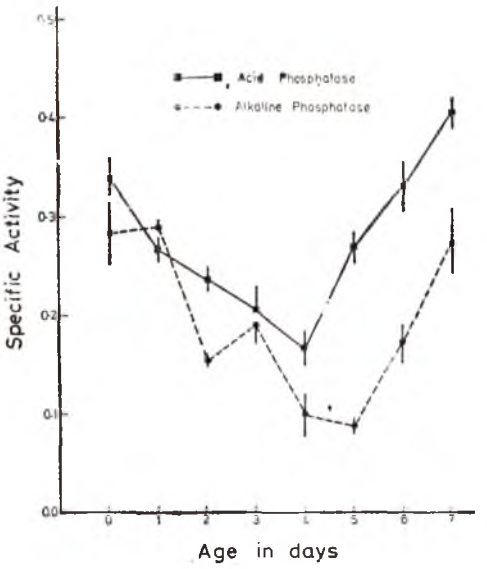

Fig. 2. Specific activities of acid- and alkaline phosphatases during pupal period of *S. mauritia*. Each point represents mean of five replicate experiments ± SD.

(Fig. 2). Total and specific activities of enzymes are high on 0 day. The enzyme activities then rapidly decline; lowest activities are found on 4th day in the case of acid phosphatase and on 5th day in the case of alkaline phosphatase. Enzyme activities then increase to about three fold on 7th day.

The results of acid and alkaline phosphatase determinations demonstrate that the activity patterns of these enzymes show more or less 'U' shaped curve during the imaginal development of *S. mauritia*. Phosphatases show high activity levels during the initial days of pupal period when larval organs are presumably undergoing histolysis and rises again during final days of pupal period when differentiation of imaginal structures take place. Phosphatases besides their role in histolysis are known to be capable of transphosphorylation reactions (HOLLANDER, 1971; REID & WILSON, 1971). It seems that phosphates liberated during histolysis may be used for the formation of cellular and subcellular structures necessary for the terminal stage of imaginal differentiation. The present findings are in agreement with the earlier observations in many tissues of holometabolous insects during pupal period (GILBERT & HUDDLESTON, 1965; ROUSELL 1971; SPATES & WRIGHT, 1975).

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BRIEF COMMUNICATION

ALKALINE AND ACID PHOSPHATASE ACTIVITIES IN THE MIDGUT OF *ROPALIDIA MARGINATA* L. (HYMENOPTERA-VESPIDAE) DURING METAMORPHOSIS

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The activities of alkaline- and acid phosphatases were studied in the midgut of *Ropalidia marginata* during metamorphosis. In each case 'U' shaped curve was found i.e., the enzymes were found in the midgut cells of larvae and feeding adults only. However activity was very weak in the lumen of the gut both in the larva and the adult. They declined with the histolysis of midgut and were practically absent during the pupal and emerging adult stage. However, the activity reappeared suddenly in the midgut epithelium of feeding adult.

(Key words: alkaline- and acid phosphatases, midgut, *Ropalidia marginata*, vespidae, metamorphosis)

Phosphatases have been studied extensively during the early development of various insects (ROBERTSON, 1936; DRILHON & BUSNEL, 1945; YAO, 1950 a; EGUCHI, 1965). However studies on the distribution and quantitative changes in the phosphatases during metamorphosis of midgut are very limited (YAO, 1950 b; SHRIDHARA & BHAT, 1963; EGUCHI & IWAMOTO, 1975). We have earlier described the metamorphic changes in the structure of midgut in *Ropalidia marginata* (CHATURVEDI & PATHAK, 1980). In the last larval stage when histolysis of the midgut epithelium begins, the cells stop their secretory activity. The undigested food is passed on into the hindgut in a sac of peritrophic membrane. The larval epithelium starts degeneration with the downward movement of faecal matter and this stage is considered as prepupal period. The degenerate larval epithelium is passed on into the lumen and a new pupal epithelium regenerates from the larval regenerate cells. The pupal epithelium is retained as functional adult epithelium. The present paper deals with alkaline and acid phosphatase activity in the midgut tissue and the lumen contents of various stages of metamorphosis. The observations are also strengthened by histochemical demonstration of these enzymes in various stages of development.

The larvae, prepupae, pupae and adults were dissected under stereoscopic binocular microscope. The midgut and its contents were separated from each other. The midgut tissue and its contents (10 individuals in each case) were homogenized separately in a glass homogenizer with a teflon pestle at 1500 rpm at 0°C. A 10% homogenate in 0.25 M sucrose was centrifuged for 20 min at 10,000 g and the resulting supernatant was used as the enzyme solution (EGUCHI *et al.*, 1972). The activity of phosphatases was measured by the rate of hydrolysis of *p*-nitrophenyl

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phosphate (EGUCHI *et al*, 1972). For histochemical demonstration of alkaline and acid phosphatases, midgut was fixed and processed as described by GOMORI (1952).

Acid phosphatase:

The larval epithelium showed strong acid phosphatase activity (Fig. 6) which decreased as the histolysis of midgut proceeded and was almost absent in the midgut cells of pupa and emerging adult. However, the activity increased abruptly in the feeding adult.

The enzyme activity in the midgut contents of larva was very low in comparison to prepupal stage. Activity increased during the degeneration of larval epithelium. In the prepupa of 48 hours the larval epithelium was sloughed off *in toto* and formed an "yellow body" which showed the maximum activity and, was higher than the activity of midgut contents of feeding adult.

Histochemical observations showed strongly positive activity for acid phosphatase in the midgut of larva. The enzyme was distributed at the peripheral part of the cells (Fig. 3). The degenerating midgut cells of prepupal stage also showed high enzyme activity (Fig. 5), However, the enzyme was not found even in traces in the pupal epithelium but it appeared abruptly in the adult epithelium (Fig. 4).

Alkaline phosphatase:

The activity of alkaline phosphatase was highest in the larval midgut tissue and decreased at the prepupal period (Fig. 6) during the histolysis of the midgut epithelium. The activity was almost absent in the pupal period but, however, was again noted in the emerging adult and peaked in the feeding adult.

The enzyme activity in the midgut contents of larva was low in comparison to the prepupa. The highest activity was recorded in the 48 hour prepupa (Fig. 6). After this stage the activity declined steeply, and in 96 hour pupa it was nearly absent. The same condition continued upto the adult stage; however activity reappeared in the feeding adult. The alkaline phosphatase activity of the gut contents of feeding adults was higher than the gut contents of larval stage.

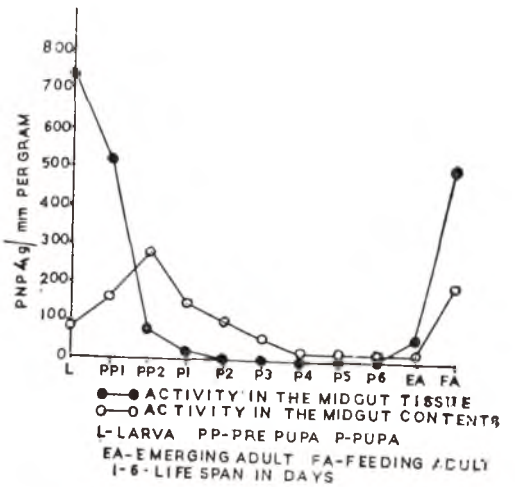

Fig. 6. Activity of acid phosphatase.

In the histochemical observations the presence of enzyme was traced at the periphery of the epithelial cells of larval midgut (Fig. 1). The degenerating prepupal epithelium also showed the presence of enzyme. However, we failed to trace the presence of enzyme in the pupal epithelium. In the feeding adult the enzyme was demonstrated in the area of striated border of epithelial cells and in the secretory vesicles (Fig. 2).

SRIDHARA & BHAT (1963) investigated the variation in the activities of the alkaline- and acid phosphatases of *Bombyx mori* during development. They reported that during the pupal stage alkaline phosphatase was almost absent, whereas acid phosphatase was maintained at a high and

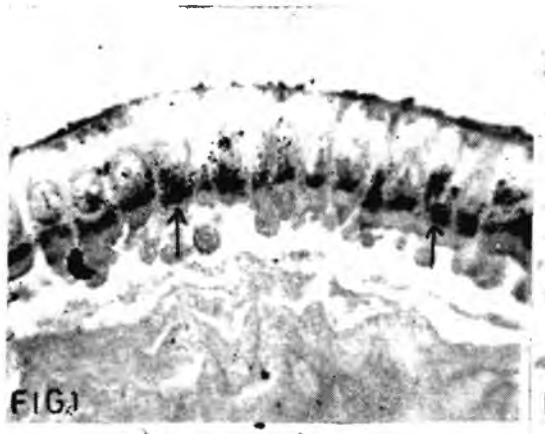

FIG.1

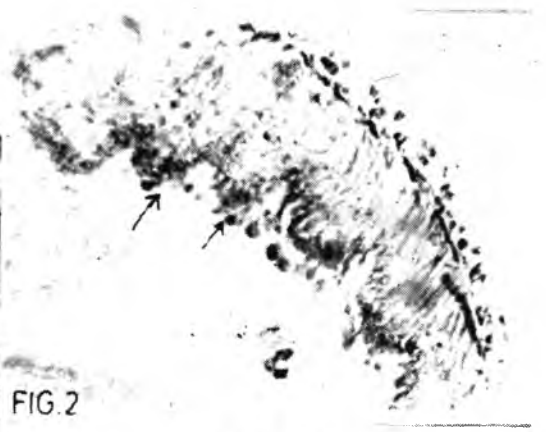

FIG.2

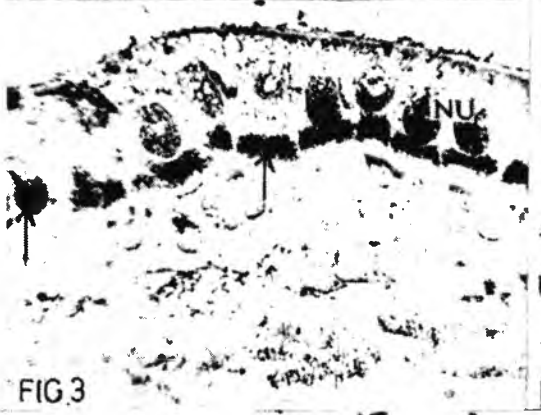

FIG.3

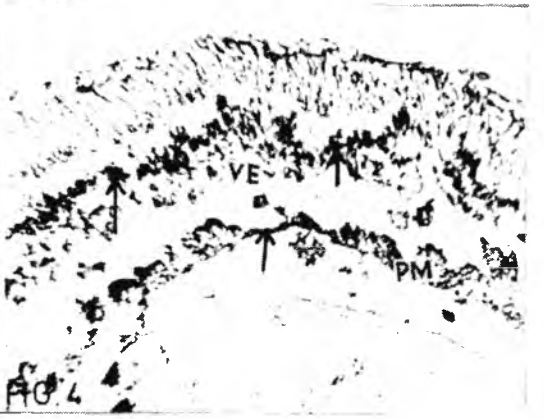

FIG.4

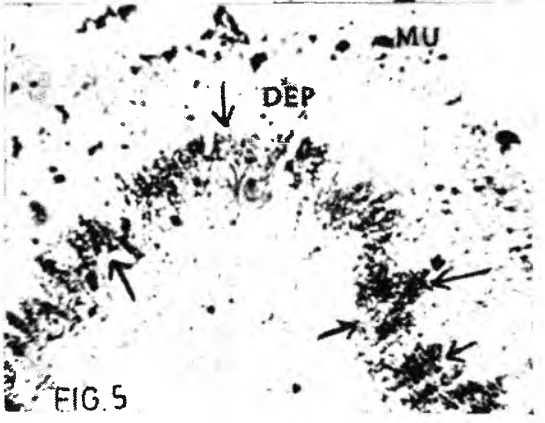

FIG.5

Figs: 1. T. S. of the midgut of feeding larva; arrows indicate the presence of alkaline phosphatase (×200); 2. T. S. of the midgut of feeding adult, arrows indicate the presence of alkaline phosphatase (×200); 3. T. S. of midgut of feeding larva, arrows indicate presence of acid phosphatase (×200); 4. T. S. of midgut of feeding adult, arrows indicate the presence of acid phosphatase (×200). 5. T. S. of midgut of 48-hr. prepupa, arrows indicate the presence of acid phosphatase (×200). Abbrevations used in Figures: DEP—Degenerating midgut epithelium; MU—Musculature; NU—Nucleus; VE—Vesicles.

constant value. However in *Ropalidia marginata* both enzymes were almost absent during pupal period. EGUCHI & IWAMOTO (1975) reported that in the silkworm larvae alkaline phosphatase is confined to the epithelium whereas pupal alkaline phosphatase is found in the 'yellow body'. These workers further mentioned that in general, the high enzyme activity tn the midgut tissue of the larva decreases steeply from spinning to the early pupal stage and the activity in the midgut content increases.

In *Ropalidia marginata* alkaline- and acid phosphatases are found in the midgut tissue of feeding larva. The activity of these hydrolysing enzymes decreases during prepupal stage. The activity further declined with the histolysis of midgut; however the activity was found high in the 'yellow body' (lumen contents of gut) in late prepupa and was nearly absent in pupal 'yellow body'. It seems quite probable that whatever enzyme activity is noted in the degenerating cells of larval midgut, is passed on into the lumen during larval pupal moulting and after histolysis the concentration of enzymes decreases in the lumen of midgut.

The presence of these enzymes in the feeding larva and feeding adult, and their complete absence in the pupal stage and also in the emerging adult indicate that they probably help in the process or digestion.

Acknowledgement: The authors are thankful to Dr. A. B. SAXENA, Professor and Head of the Department of Zoology, Madhav Science College, Vikram University, Ujjain for providing all necessary facilities during the course of this work. Thanks are also due to the Director, British Museum, London for identification of insects, and to Dr. M. N. S. IYENGAR, Deputy Director, C. S. R. & T. I., Mysore, for critically reading through the manuscript.

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BRIEF COMMUNICATION

ON TWO NEW APHID PARASITOIDS OF GENUS *TRIOXYS* (APHIDIIDAE : HYMENOPTERA) FROM KASHMIR, INDIA

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(Received 14 June 1981)

Two new aphid parasitoids *viz.*, *Trioxys (Binodoxys) jaii* reared from *Shivaphis celti* Das and *Aphis craccivora* Koch, and *Trioxys (Trioxys) rosaecola* reared from *Myzaphis rosarum* (Kaltenbach) are described in the present paper.

(*Key words:* taxonomy, *Trioxys (Binodoxys) jaii* sp. nov., *Trioxys (Trioxys) rosaecola* sp. nov.)

Recently the extensive surveys with respec to the hymenopterous parasitoids attacking the aphids of Kashmir have been conducted by Stary and Bhagat (1978) and Bhagat (1980). During the course of this study, two new aphid parasitoids belonging to the genus *Trioxys* have been encountered from this region. The females of these two new species *viz.*, *Trioxys (Binodoxys) jaii* and *Trioxys (Trioxys) rosaecola* are described in this communication by the present author.

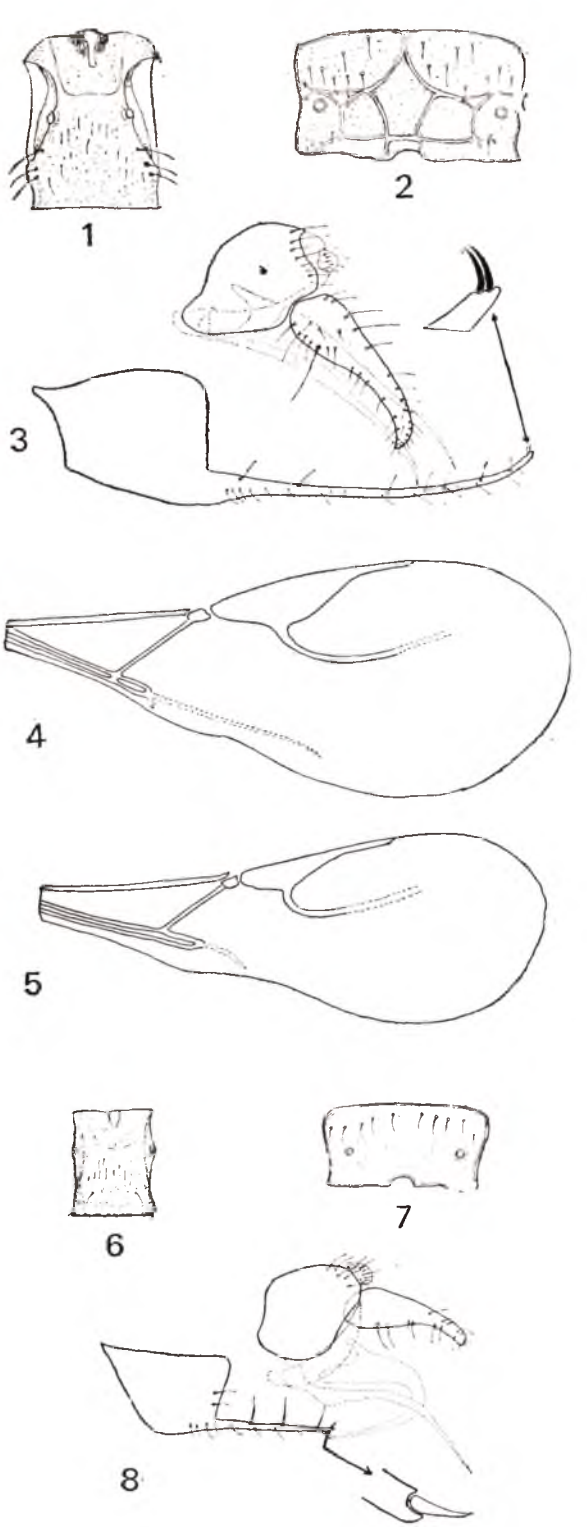
The type material will be deposited in the Museum of P. G Department of Zoology, Kashmir university.

1. Trioxys (Binodoxys) jaii, sp. nov. (Figs. 1-4)

Description: Head transverse, smooth, shining and sparsely haired. Eyes oval, small and prominent. Gena equal to 1/3 of the longitudinal eye diameter. Interocular line 1.6 times longer than the transfacial line. Clypeus with 4 long hairs. Tentorio-ocular line 1/5 of intertentorial line. Antennae 11 segmented. F_1 (= first flagellar segment) five times as long as wide, nearly equal to F_2.

Thorax: Mesoscutum with distinct notaulices present anteriorly and effaced on the discs. Propodeum (Fig. 2), completely areolated with distinct central pentagonal areola just before the beginning of tergite I with two adjacent quardate areolae. Forewing having pterostigma nearly three times as long as wide. Metacarpus is equal to the width of pterostigma. Radial vein equal to the length of pterostigma (Fig. 4).

Abdomen: Tergite (Fig. 1), more than twice as long as wide at the spiracles, width across the secondary tubercles 1.5 times longer than width at the spiracles. Interspiracular distance is distinctly longer than the distance between 1st and 2nd lateral tubercles. Lateral portion of the tergite I from apex to the secondary tubercles is prominently concave and parallel sided towards the posterior side. Genitalia (Fig. 3), ovipositor sheaths slender, lower edge is strongly concave and moving downwards. Prongs slenderer, slightly arcuate, dorsally having 7-8 short hairs and at the apex there are present two claw shaped bristles.



Figs (1—8): *Trioxys (Binodoxys) jaii*, sp. nov.: 1. tergite I; 2. propodeum; 3. genitalia; 4 · forewing. *Trioxys (Trioxys) rosaecola*, sp. nov., 5. forewing; 6. tergite I; 7. propodeum; and 8. genitalia.

Colouration: Head dark brown, clypeus and mouth-parts yellowish brown. Antennae dark brown, scape, pedicel and F_1 yellowish brown. Thorax dark brown. Wings hyaline and venation brown. Tergite I light brown. Legs yellowish. Abdomen also yellowish with lateral spots. Ovipositor sheaths yellowish brown apically and prongs yellowish.

Length of the adult : 2.9-3.2 mm.

Male: Unknown.

Mummy: Light brown.

Holotype: ♀, INDIA: KASHMIR (Srinagar), 21.v.1975, from *Shivaphis celti* Das on *Celtis australis*, **Paratype :** 2 ♀♀ with collection data same as for the holotype and 4 ♀♀ from *Aphis craccivora* Koch on *Robinia pseudoacacia*, Hazratbal, Srinagar, Kashmir, 25.vi.1975, coll. R. C. Bhagat.

Remarks: This new species comes close to *Trioxys (B). orientalis* Stary and Schlinger (1967) in shape of genitalia. However, it differs from it in the shape of forewing, propodeum and tergite I.

2. Trioxys (Trioxys) rosaecola, sp. nov. (Figs. 5-8).

Description: Head having gena equal to 1/8 of longitudinal eye-diameter. Tentorio-ocular line 1/4 of intertentorial line. Eyes oval. Interocular line 1.5 times longer than transfacial line. Antennae filiform, 12 segmented, reaching the tergite I. Flagellar segment 1 (= F_1), 4.5 times as long as wide and little longer than F_2

Thorax: Mesoscutum with notaulices effaced on the discs. Propodeum (Fig. 7), smooth with about 10 hairs at the anterior side. Forewing (Fig. 5), pterostigma 3.2 times as long as wide; metacarpus nearly equal to half of pterostigma length, radial vein 3 times as long as pterostigma width.

Abdomen: Tergite I (Fig. 6) less than twice as long as wide, smooth and shining. Spiracular tubercles are less prominent and are situated at the upper half. Genitalia (Fig. 8), ovipositor sheaths slender, apical part narrower and curved downwards with sparse hairs. Prongs entirely straight with 3 long hairs on the dorsal surface, at the apex is present a single basally dialted bristle.

Colouration: Head black, clypeus and mouth-parts (excepting apical parts of mandibles) yellowish. Antennae brown; scape, pedicel and F_2 and F_3 brownish yellow. Thorax black. Wings hyaline and venation yellowish. Legs brownish. Abdomen yellowish. Propodeum brownish yellow. Ovipositor sheaths brownish and prongs yellowish.

Length of the adult body : 3.2 mm.

Male: Unknown.

Mummy: Light brownish.

Holotype ♀: INDIA : KASHMIR (Srinagar), 20.vi.1976, from *Myzaphis rosarum* (Kaltenbach) on *Rosa webbiana*. **Paratype** 1 ♀, with collection data same as for holotype.

Remarks: Trioxys (T.) rosaecola n. sp. comes close to *T. (T.) chaetosiphonis* Stary *et al.*, (1971), from France, however, differs in having tergite I stouter with less prominent spiracular tubercles, propodeum with sparse hairs, ovipositor sheaths anteriorly slenderer and female 12 segmented.

Acknowledgement: The author is thankful to Dr. D. N. Fotedar, Head, P. G. Department of Zoology, Kashmir University for providing all necessary working facilities and encouragements.

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BRIEF COMMUNICATION

HITHERTO UNKNOWN ALATE MALE OF *PERIPHYLLUS AESCULI* HRL FROM UTTAR PRADESH

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(Received 14 June 1981)

Hitherto unknown alate male of *Periphyllus aesculi* Hille Ris Lambers collected from Uttar Pradesh is described.

(Key words: hitherto unknown alate male *Periphyllus aesculi* HRL)

Genus *Periphyllus* van der Hoeven is known in India by 8 species. Out of these *P. aesculi* Hille Ris Lambers is also known by apterous oviparous female and *P. villosii* Chakrabarti is known by both alate male and apterous oviparous female in addition to viviparous morphs (Basu and Raychaudhuri, 1980). Hitherto unknown alate male of *P. aesculi* can be separated from the only other known alate male of *P. villosii* by the following key characters:

Processus terminalis 1.95—2.0 × the base of antennal segment VI and 2.12—2.40 × length of antennal segment III; antennal segment III, IV and V with 65—90, 35—49 and 11—20 secondary rhinaria respectively; ultimate rostral segment as long as second joint of hind tarsus; on *Aesculus indica*

..... *P. aesculi* Hille Ris Lambers

Processus terminalis 3.5—4.6 × the base of antennal segment VI and 0.65—0.75 × length of antennal segment III; antennal segments III, IV and V with 98—112, 55—92 and 9—19 secondary rhinaria respectively; ultimate rostral segment 0.54× the second joint of hind tarsus; on *Acer villosum*

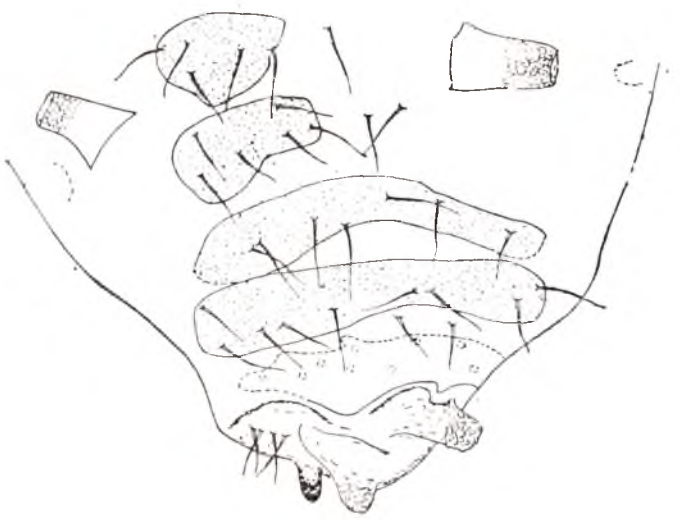
..... *P. villosii* Chakrabarti

Periphyllus aesculi HRL.

Alate male: Body 3.15-3.75 mm long with 0.9-1.19 mm as maximum width. Head dark brown, longest hair on vertex about 195-225 μm long and about 4.33-5.66 × basal diameter of antennal segment IV. Antennae brown, about 0.72-0.8 × body, flagellum imbricated; processus terminalis about 1.95-2.0 × base of antennal segment VI and about 2.12-2.40 × antennal segment III; antennal segment III with 65-90, IV with 35-49 and V with 11-26 secondary rhinaria; hairs on flagellum long and fine, segment III with 12-20, IV with 7-12, V with 5-7 and base of segment VI with 1-4 hairs, longest hair on segment III about 3.66-4.33 × basal diameter of the segment. Ultimate rostral segment about as long as second joint of hind tarsus. Thorax pale brown with dark brown mid-thoracic lobe. Abdominal dorsum with dark brown patches distributed as:

Spinal patches — on segments 1 to 7
Pleural patches — on segments 2 to 7
Spino-pleural patches — on segment 8;

*late Professor D. N. Raychaudhuri



Periphyllus aesencli HRL : Portion of abdomen showing male genitalia

longest hair on anterior tergites about 4.0 5.66 × basal diameter of antennal segment III. Siphunculi dark brown but apical rim is pale, reticulated over almost the entire length, about 1.12-0.18 mm long and 0.036-0.054 × body and about 0.89-1.2 × its maximum diameter at base. Cauda transversely semioval bearing 6-7 long hairs. Legs pale brown. Male genitilia well-developed. Other characters as in alate viviparous female (Chakrabarti, 1972).

Measurements of one specimen in mm : Length of body 3.75, width 1.17; antenna 2.7, antennal segments III : IV : V : VI : 0.82 : 0.64 : 0.49 : (0.19 + 0.35); ultimate rostral segment 0.19; second joint of hind tarsus 0.18; siphunculus 0.14.

Material examined : INDIA, UTTAR PRADESH: 1 alate ♂, 4 apterous oviparous ♀♀ and 3 apteroid nymphs from *Aesculus indica*, Nainital (*c* 2270m), 5.xii.1979; 1 alate ♂ and II apteroid nymphs from *A. indica*, Ranikhet (*c* 1875m), 6.xii.1979; 2 alata ♂♂, 6 apterous oviparous ♀♀ and 14 apteriod nymphs from *A. indica*, Almorah (*c* 1600 m), 7.xii.1979. Collectors : BKA and D. Ghosh,

Acknowledgements: Thanks are due to Head of the Department of Zoology, for providing laboratory facilities and to the department of Botany for comments on the identity of the host plant.

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BRIEF COMMUNICATION

STUDY ON APHID TENDING ANTS IN INDIA . I. NEW RECORDS OF APHID AND ANT SPECIES IN THEIR ASSOCIATION

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(Received 7 October 1981)

One subfamily, 1 genus and 4 species of ants are reported here as new records from India in respect of their aphid association. Besides, two species of aphids are reported as myrmecophilous for the first time.

(*Key words:* new records, ant-aphid association)

Out of about 720 aphid species (Raychaudhuri, D. N. ed., in press) recorded from India, only about 100 species are known to be tended by about 37 species of ants besides a few undetermined ones as revealed by earlier studies. (Behura, 1963, 1965; Behura and Mahapatra, 1968; David *et al.*, 1967; Ghosh, 1979; Ghosh and Raychaudhuri, 1973; Joshi and Mathur, 1967; Kurl and Misra, 1980; Misra and Behura. 1969; Roy and Behura, 1980; Sengupta, Das and Behura, 1962).

With a view to study the aphid-ant complex, different parts of the country are being surveyed. Examination of a part of the material so far studied in the states of West Bengal and Sikkim revealed that it includes 1 subfamily, 1 genus and 4 species of ants as new records from India in respect of their aphid association and 2 species of aphids have been found as new records in respect of ant attendance. New Indian records of the ant species have been denoted by one * and those of aphids by two **.

Subfamily FORMICINAE

1. ***Camponotus** nr. **binghami** Forel

Material examined : 2 ♀♀ tending *Aphis craccivora* Koch on *Dolichos lablab*, loc. West Bengal : Calcutta, 22.i.1981.

2. **Camponotus compressus** Fabricius

Material examined : 7 ♀♀ tending *Rhopalosiphum maidis* (Fitch) on *Zea mays*, loc. West Bengal : Calcutta, 11.v.1981.

3. **Paratrechina** spp.

Material examined ; 2 ♀♀ tending ***Sinomegoura photinae* (Takahashi) on *Photinia* sp., loc. Sikkim : Singtam, 14.xi.1976; 7 ♀♀ tending *Paraoregma alexanderi* (Takahashi) on bamboo plant, loc. Sikkim : Namchi, 10.xii.1976; 5 ♀♀ tending ***Aulacorthum magnoliae* (Essig and Kuwana) on *Colocasia* sp., loc. Sikkim : Namchi, 10.xii. 1976; 2 ♀♀ tending *Greenidea (Trichosiphum) formosana heeri* Raychaudhuri *et al.* on *Psidium guajava*, loc. Sikkim : Singtam, 3.v.1977; 3 ♀♀ tending *Macrosiphoniella sanborni* (Gillette) on *Chrysanthemum* sp., loc. West Bengal: Calcutta, 20.v.1981; 1 ♀ tending *Rhopalosiphum maidis* (Fitch) on *Zea mays*, loc. West Bengal : Calcutta, 11.v.1981.

Subfamily MYRMICINAE

4. Crematogaster politula Forel

Material examined : 2 ♀♀ tending *Greenidea ficicola* Takahashi on an indet host plant, loc. Sikkim : Namchi, 3.i.1977.

5. *Monomorium gracillimum Smith

Material examined : 2 ♀♀ tending *Macrosiphoniella sanborni* (Gillette) on *Chrysanthemum* sp., loc. West Bengal : Calcutta, 20.v.1981.

6. Solenopsis geminata Fabricius

Material examined : 3 ♀♀ tending *Pentalonia nigronervosa* Coquerel on *Musa* sp. loc. Sikkim : Singtam, 14.xi.1976.

7. Tetramorium bicarinatum (Nylander)

Material examined : 2 ♀♀ tending *Sinomegoura photinae* (Takahashi) on *Photinia* sp., loc. Sikkim : Singtam, 14.xi.1976.

Subfamily PSEUDOMYRMECINAE

8. Tetraponera rufonigra Jerdon

Material examined : 2 ♀♀ tending *Lipaphis erysimi* (Kalt.) on *Brassica* sp., loc. Sikkim : Namchi, 10.xii.1976.

Subfamily *PONERINAE

9. Diacamma nr. **rugosum** Le guillon

Material examined :2 ♀♀ tending *Aphis gossypii* complex on *Gossypium* sp., loc. West Bengal : Calcutta, 12.xii.1980.

This subfamily was hitherto unknown in respect of aphid association from India.

Acknowledgements: Authors express sincere sense of gratitude to the late Professor D. N. Raychaudhuri for suggsting the problem. Thanks are due to Dr. Keiichi Onoyama, Obihiro University of Agriculture & Veterinary Medicine, Japan and Mrs. R. Mathew, Zoological Survey of India for their kind help in the identification of some of the ant species. Thanks are also due to the Head of the Dept. of Zoology, University of Calcutta for providing laboratory facilities.

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BRIEF COMMUNICATION

FIRST RECORD OF THREE HYPERPARASITOIDS OF *TRIOXYS (BINODOXYS) INDICUS* SUBBA RAO SHARMA (HYM : APHIDIIDAE) FROM INDIA

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The paper reports the existence of three hyperparasitoids *viz., Aphanogmus* sp., *Ceraphron* sp. and *Litomastix* sp. (Hym. : Encyrtidae) of *Trioxys (Binodoxys)* newly from India.

(*Key words:* new report, hyperparasitoids)

Two hyperparasitoids, *viz.*, *Lygocerus* sp. (Hym. : Ceraphronidae) and *Charips* sp. (= *Alloxysta* sp.) of *Trioxys (Binodoxys) indicus* SUBBA RAO & SHARMA (Hym. : Aphidiidae), a native parasitoid of *Aphis craccivora* Koch (Hym. : Aphididae) were reported by SUBBA RAO & SHARMA (1962) from Delhi.

Two other hyperparasitoids, viz., *Alloxysta pleuralis* Cameron (previously noted as *Alloxysta* sp. nr. *pleuralis* Cameron, but later on H. H. Evenhuis has confirmed the species as *A. pleuralis)* and *Phaenoglyphis* sp. (Hym. : Cynipidae) were recorded from eastern U. P. (Singh & Sinha, 1979; Singh *et al.*, 1981).

Recent collections of parasitic wasps by the authors have further revealed the existence of three more hyperparasitoids of *T. indicus*, *viz.*, *Aphanogmus* sp., *Ceraphron* sp. (Ceraphronidae) and *Litomastix* sp. (Hym. : Encyrtidae). The above species of Ceraphronidae were previously recorded as parasitoids of dipteran hosts (Thomson, 1953; Chatterjee & Misra, 1974; Dessart, 1979) and as hyperparasitoid of a braconid wasp (Rao & Ali, 1976). We record *Aphanogmus* and *Ceraphron* for the first time from India hyperparasitising an aphidiid parasitoid, *T, indicus* (indirect host-*A. craccivora)*. *Litomastix* spp. are mostly recorded as parasitoids of lepidopteran hosts (Thomson, 1953; Chatterjee & Misra, 1974), *T. indicus* is a new host of *Litomastix* sp. and is the first recorded from India.

The hyperparasitisation of *T. indicus* by the above mentioned three species starts by the end of the season, *i. e.*, during the months of March and early April in contrast to the hyperparasitisation by *A. pleuralis* and *Phaenoglyphis* sp. in which hyperparasitisation begins by the start of January and continues to the end of the season causing mortality of the parasitoid to the extent of 3% (Singh & Sinha, 1980). The magnitude of hyperparasitisation of *T. indicus* by *Aphanogmus* sp., *Ceraphron* sp. and *Litomastix* sp. is very low (only few specimens were obtained).

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BRIEF COMMUNICATION

FOOD PREFERENCE TO *HOLOTRICHIA CONSANGUINEA* BLANCHARD (COLEOPTERA : SCARABAEIDAE)*

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Food preference to chafer beetle, *Holotrichia consanguinea* Blanchard was studied by intake method of twelve feeds. Maximum intake was recorded in guava followed b, *neem*. It was least in mango. The food intake by the beetles in order of perference was guava, neem, bar, karaundha, litchi, blackberry, grape, citrus, amla, shesham, pomegranate and mango.

Key words: food preference, chaffer beetles, *Holotrichia consanguinea)*

The chafer beetles *(Holotrichia consanguinea* Blanchard) are potent source of white grub a serious damaging stage which has posed an alarming situation threatening therewith groundnut cultivation in Uttar Pradesh and adversely affecting vegetable oil industry of the country. They are polyphagous, feed on various trees by accumulating in large numbers and devouring their leaves (SRIVASTAVA & KHAN, 1963; VISHWA NATH, 1977; DHALIWAL & SINGH, 1978; YADAVA *et al.*, 1978; VEERESH *et al.* 1978 and BATRA, 1979).

Food preference to various feeds to facilitate integrated pest centrol operations against this noxious pest of national importance was studied by intake method. Twelve feeds each in 20 gm were kept in 2.5 kg capacity round glass jars replicated thrice. Ten overnight starved beetles were released in each jar at dusk. The opening of jars was covered with muslin cloth and tied with rubber bands. Observations were recorded in the following morning by weighing the left over feeds

TABLE 1. Food intake by beetles *Holotrichia consanguinea* Blanchard.

Feeds		Average food intake (gm)
Guava	*Psidium guajava* Linn.	8.03 (2.82)
Mango	*Mangifera indica*	8.83 (0.90)
Karaundha	*Carissa carandus* L.	4.36 (2.08)
Neem	*Azadirachta indica* A. juss	6.33 (2.51)
Shesham	*Dalbergia sissoo*	1.90 (1.37)
Grape	*Vitis vinifara* M.	2.93 (1.69)
Blackberry	*Eugenia jambolana*	3.10 (1.74)
Amla	*Emblica officinalis*	2.06 (1.42)
Ber	*Zizyphus jujuba* Mill.	5.10 (2.25)
Litchi	*Litchi chinensis*	3.80 (1.94)
Pomegranate	*Punica granatum*	1.33 (1.14)
Citrus	*Citrus reticulata*	2.50 (1.58)
SEM ±		0.25
CD at 5% level		0.52

Figures in parentheses are transformed values (tx)

*Part of M.Sc. (Ag.) thesis of senior author.

for the assessment of actual intake of food by the beetles. The data were subjected to statistical analysis and findings are presented in the Table.

It is apparent from the Table that the maximum intake of food by the beetles was highest in guava followed by neem which were at par and significantly superior to other feeds. The food intake in mango was least and do not differ significantly from shesham and pomegranate. The food intake by the beetles in order of preference is guava, neem, ber, karaundha, litchi, blackberry, grapes, citrus, amla, shesham, pomegranate, and mango.

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REPORTS AND NEW RECORDS

SEXUAL DIMORPHISM IN *DANAIS CHRYSIPPUS* (DANAIDAE: LEPIDOPTERA)

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Sexual dimorphism in insects is helpful for effective pest control. In *Danais chrysippus* the sexes are distinguished by the length of the antennae, spots on the wings and in the size of the leg with the distribution of hairs.

(*Key words:* clavate antenna, black spots, discal cell, pouch, coxa, tarsal segment).

A knowledge of the sexual dimorphism in insects of economic importance is helpful in the identification of the sex of the insect pest and in ascertaining the proportion of males to females in a population for effective pest control. *Danais chrysippus*, the common monarch butterfly chosen for the present study, is encountered on the plains of South India, and the larvae of this insect feeds voraciously on the green succulent leaves of *Calotropis gigantia*, which is extensively used as a green manure. The present note deals with the sex dimorphic characters that distinguish the males from the females in *D. chrysippus*.

Studies have brought to light that differences in the lengths of the antennae, spots on the wings, size of the legs with the distribution of hairs, serve to distinguish the male from the female. The males possess four small black spots around the discal cell (Fig. 1), on their hind wings whereas the females have only three such spots (Fig. 2). Further, the hind wings of the male are characterised by the presence of a pouch which is absent on the hind wings of the female. This pouch of the male is regarded as a scent producing structure (Nayar *et al.*, 1976) probably for attracting the opposite sex, a feature which has been reported for an allied species, *Danaus limniace* (Talhot, 1947). The length of the black clavate antenna of the male is found to be a little greater (1.5 cm) than that of the

Sexual dimorphism in *Danais chrysippus* Fig. 1. Adult male insect. Note the presence of four black spots on upper hindwing; Fig. 2. Adult female insect. Note the presence of three black spots on upper hindwing; Fig. 3. Prothoracic leg of male insect with a tuft of hair on coxa and narrow tarsal segments without hooks; 4. Prothoracic leg of female insect with six hooks on the broad tarsal segment.

female (1.2 cm). The prothoracic leg of the male insect is endowed with fine hairs on its narrow tarsal segments and a tuft of hairs on its coxa (Fig. 3). In the female, instead of these hairs, spines (three in number) are present on its broad terminal tarsal segment (Fig. 4). In general, the members of the family *Danaidae* seem to exhibit sex dimorphic features in their forelegs which are usually narrow and pointed in males as it has been reported for *D. chrysippus*.

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RECORD OF SOME HYMENOPTEROUS PARASITES OF THE SUGARCANE LEAF ROLLR, *NEOMARASMIA SUSPICALIS* WKR.

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(Received 9 August 1981)

Eight species of hitherto unknown hymenopterous parasites on sugarcane leaf roller *Neomarasmia suspicalis* are recorded for the first time.

(Key words: hymenopterous parasites, *Neomarasmia suspicalis)*

The leaf roller, *Neomarasmia suspicalis* Wkr. is a new pest of sugarcane recorded at Lucknow (Kalra *et al.*, 1966). Rearing of the field collected larvae in the laboratory yielded eight species of hitherto unknown parasites during the period July through September 1970.

1. *Goniozus borneanus* Cam. (Bethylidae)

The adults emerged from brown cocoons after 5 to 8 days pupation and they lived for 8-12 days.

2. *Apanteles cypris* Nixon (Braconidae)

The parasite larvae pupated outside the host body singly in white cocoons. A maximum of 14 larvae were observed to successfully complete their life cycle on a single host caterpillar. The pupal period was 8 to 10 days.

3. *Bracon* sp. (Braconidae)

The parasite larvae pupated on the leaf surface in masses of 5 to 12. The pupal period lasted about 5 days. Females were preponderant.

4. *Cardiochiles* sp. (Braconidae)

Only a single specimen of this very active parasite was obtained. The dirty white cocoon was attached to the leaf surface by the side of the parasitised caterpillar.

5. *Macrocentrus* sp. (Braconidae)

Four to six cocoons were formed from a single parasitised caterpillar. The cocoons were brown in colour and are covered with thin white silk.

6. *Elasmus brevicornis* (Elasmidae)

7. *Eurytoma* sp. (Chalcidae)

These are ectoparasites and were reared from the larvae of leaf roller, 10 to 15 larvae developing on one caterpillar.

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Thanks are due to the Director, Commonwealth Institute of Entomology, London, for identification of these parasites.

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RECORD OF A HYPERPARASITOID *EUPTEROMALUS* SP. NEAR *PARNARAE* GAHAN (HYMENOPTERA : PTEROMALIDAE) FROM THE PUNJAB, INDIA

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Eupteremalus sp. is recorded for the first time in India on *Apanteles flavipes*.

(Key words: Eupteromalus sp. hyperparasitoid, *Apanteles flavipes)*

Apanteles flavipes (Cameron) is a very common endoparasitoid of lepidopterous larvae. It is present throughout the year on *Acigona steniella* (Hampson), *Chilo infuscatellus* (Snellen) both serious pests of sugarcane, and *Chilo partellus* (Swinhoe), a serious pest of maize, in the Punjab. Its incidence of parasitism on *A. steniella* varies from 2 to 28 per cent in nature (Varma *et al.*, 1981).

During a survey for the natural enemies of *A. steniella* in the state, the cocoons of *A. flavipes* were collected from a stubble containing a dead *A. steniella* larva from Adampur (Jullundur) during May, 1978. From these cocoons not only the adults of *A. flavipes* but also of *Eupteromalus* sp. near *parnarae* Gahan emerged. The *Eupteromalus* sp. was considered as a hyperparasitoid and this type of parasitism was confirmed in the laboratory by exposing the laboratory reared cocoons of *A. flavipes* to its females. The cocoons of *A. flavipes* were exposed for 24 hours in test tubes (10 cm × 2 cm). The hyperparasitoid completed the life cycle in 10 days at 26.2 ± 1°C and 70 ± 5.4 per cent relative humidity in the laboratory. It was reared for two generations. The adult longevity was 5.1 ± 1.52 days ($n = 10$) in case of males and 5.66 ± 1 days ($n = 9$) in case of females when fed on 30 per cent honey solution.

The first record of *E. parnarae* to which this species is near, dates back to 1919 when Gahan reported it from India as a parasite of *Pelopidas mathias* (Fabricius) on rice. Later on it was recorded from the eggs of *Oxya intricata* (Stal.) parasitized by *Scelio oxyae* Timberlake (Chiu and Chou, 1974), larvae of *Spodoptera litura* Fabricius parasitized by *Snellenius manilae* (Ashmead) (Chiu and Chou, 1976) and pupae of *Apanteles baoris* Wilkinson, a larval parasitoid of *Parnara guttata* (Bremer and Grey) (Tachikawa and Sasaki, 1977). The *O. intricata* and *S. litura* are pests of rice in Taiwan and *P. guttata* in Japan. Catling (1979) recorded it from the eggs of *Tryporyza incertulas* (Walker) a pest of rice, from Joydevpur (Bangladesh). Recently, Ooi (1980) reported it from Malaysia as a hyperparasitoid of cocoons of *Apanteles plutellae* Kurdyuko, a parasitoid of *Plutella xylostella* Linnaeus on cabbage.

The present investigation confirmed the previous reports except that of Gahan (1919) and Catling (1979) who reported it as a parasitoid of *P. mathias* and *T.*

incertulas respectively. This is the first record of *Eupteromalus* sp. on *A. flavipes* in India.

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EFFICACY OF ASCORBIC ACID AND ACETIC ACID AS GRAIN PROTECTANTS AGAINST, THE RICE WEEVIL, *SITOPHILUS ORYZAE* L.

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Effects of 2% ascorbic acid and 1% acetic acid on the infestation of wheat grains during storage by *Sitophilus oryzae* was studied. Grains were either directly treated with the chemicals and stored in glass vials or jute-bags treated with the chemicals were used for storage of grains and kept for observation for 3 months. No appreciable infestation occurred till 10 weeks in the acetic acid treated seeds but under similar conditions effects of ascorbic acid was not appreciable. Infestation of grains stored in treated jute-bags was significantly checked for 3 months.

(*Key words:* ascorbic acid, acetic acid, grain protectants, rice weevil, *Sitophilus oryzae*)

INTRODUCTION

It is estimated that about 10-20 per cent of the total agricultural produce are destroyed during their storage. Storage of food grains is essential for meeting an emergency demand due to accidental failure of harvest, for seed purpose and to meet ever increasing international trade in plant products, the latter being a major factor accelerating the global spread of plant pests and pathogens. Storage methods for large or small quantity of food grain should also be economic and simple and it needs careful attention for quality maintenance. Treating of containers with chemicals which prevent pest infestation, constitute a suitable method of short term storage. Some data on short term grain protection by chemicals having no serious toxic hazards are presented in this paper.

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MATERIALS AND METHODS

Sitophilus oryzae L., rice weevil procured from local store house was reared in the laboratory on wheat, *Triticum aestivum*. Ascorbic acid 2 per cent and acetic acid 1 per cent were used as the test chemicals. Wheat grains were carefully selected and sterilised before use. Batches of twenty selected grains were treated separately with 0.4 ml of the solutions and dried before storing in glass vials covered with thin muslin cloth. Ten adult insects, 5 of each sex were released in each vial for infestation of the grains. Number of infested grains, weight of the feeding dust, number of living insects, larvae and pupae were recorded for 10 weeks after the release. Experiments were repeated ten times with equal number of replicate for each experiment.

Small jute-bags soaked in 2% ascorbic acid or 1% acetic acid solutions were air-dried and sealed with 500 gm of sterilised seeds. These bags were left in glass jars covered with cloth, each containing 50 adult insects of both sexes. Infestation was studied by checking the weight of the feeding dust and number of larvae in each month for three consecutive months. The distribution test (t-test) was performed for statistical analysis of the data.

RESULTS

After one week there was no feeding in the treated vials, whereas, about 10 per cent grains were fully infested in the control groups. Till 4th week there was no feeding in the acetic acid treated vials and by the 5th week 80-90 per cent of these insects died. Till 10 weeks infestation by the remaining insects was very negligible. After two weeks, considerable feeding was found in ascorbic acid treated vials and the weight of dust was 0.0033 gm which gradually increased to 1.8570 gm upto 10th week. Mating was observed in these vials from 2nd week leading to increase of population which ended in the 10th week with 79 adults, 121 larvae, 58 pupae, however these were respectively 42, 36 and 55 per cent less than control (Table 1).

Result of feeding and growth in the experiment on treated jute bags are given in (Table 2). Up to one month no feeding was observed in the treated bags, whereas in the control bags significant amount of feeding dust was obtained during the same period. After two months weights of feeding dust were 0.0214 g and 0.0892 g respectively in the ascorbic acid and acetic acid treated bags. This was 98 and 95 per cent less than the feeding in the corresponding control bags. Number of larvae were 6 and 8 against 26 and 35 in the control. After 3 months weight

TABLE 1. Effect of 2% ascorbic acid treatment of wheat grains on the feeding and development of *Sitophilus oryzae* L.

A	B	C	D	E	F
1	(2*)	(0.0043)*	10 (10)		
2	2 (7)	0.0033* (0.0067)	10 (10)		
3	3 (8)	0.0042* (0.0071)	10 (10)		
4	3* (10)	0.0075* (0.0321)	10 (10)	11 (17)	
5	7* (11)	0.0120* (0.0471)	6 (8)	17* (29)	6 (8)
6	12 (14)	0.0573* (1.2689)	3* (8)	33* (41)	19* (30)
7	16 (15)	1.2120* (1.3130)	7* (8)	49* (53)	27* (53)
8	19 (20)	1.3527* (1.4938)	23 (41)	68* (81)	33* (76)
9	20 (20)	1.6122* (1.7330)*	48* (89)	93* (107)	47* (97)
10	20 (20)	1.8570* (2.9322)	79* (137)	121* (190)	58* (131)

i) Figures in parenthesis indicate control values. ii) *Significant at 5% level. iii) A—weeks after treatment, B—No. of total infested grains, C—Weight of dust in g, D—No. of adult insects, E—No. of larvae, F—No. of Pupae.

TABLE 2. Infestation and development of *Sitophilus oryzae* in wheat, stored in ascorbic and acetic acid treated jute bags.

Months after treatment	Ascorbic acid 2 per cent		Acetic acid 1 per cent	
	Weight of dust in gm	No. of larvae	Weight of dust in gm	No. of larvae
One month	(.0239)*	(12)*	(.0212)*	(17)*
Two months	.0214* (1.4086)	6* (26)	.0892* (1.7612)	8* (35)
Three months	1.5839* (2.5290)	28* (40)	1.7302* (3.9763)	23* (88)

i) Figures in parenthesis indicate control values. ii) *Significant at 5 per cent level.

of the feeding dust further increased and this was 38, 56 per cent less than the control respectively in the ascorbic acid and acetic acid treatments. Number of larvae during the same period were 28 and 23 against 40 and 88 of the respective control.

DISCUSSION

Several attempts have been made to protect food grains during storage either by directly treating the grains or the containers with various insecticides. Considerable protection against adults of storage insects was obtained by impregnating jute-bags or containers with various organic insecticides (COTTON *et al.*, 1944; PINGALE, 1953; PALI, 1960; JOSHI & KAUL, 1966; MOOKHERJEE & BOSE, 1967).

But, only scanty reports are available on the protection of grains during storage with non-insecticidal compounds. WILKIN & THOMAS (1970) have shown that application of one per cent propionic acid applied to stored barley provides slight initial insecticidal action but it confers no protection against infestation by insects. In the present investigation partial and total protection of wheat grains was obtained against *Sitophilus oryzae* L. by directly treating the grains with 2 per cent ascorbic acid, and 1 per cent acetic acid. Significant protection against *S. oryzae* was obtained by impregnating jute-bags with the same concentrations of ascorbic acid and acetic acid. These compounds are biodegradable and constitute source of carbon atoms in organisms and have no toxic hazards on non-target organisms. Nearly full protection of grains was observed up to 10 weeks by directly treating the seeds with acetic acid and protection due to ascorbic acid by similar treatment was not remarkable though damage was significantly less than the control. Mating was completely checked due to acetic acid treatment but only partial inhibition was obtained in the ascorbic acid treatment. However, ascorbic acid offered better protection when the jute-bags were impregnated. In the sack-impregnation method, infestation till 2 months was negligible. Entry of the weevils was restricted and most of those which entered into the acetic acid treated bags could not survive. Sterility of *Dysdercus koenigii* F. by acetic acid has been reported (DATTA & BANERJEE, 1978). Protective action of the chemicals gradually diminished after 3 months which was evident

by the increase in the number of larvae. The quality of the grains was not affected in the jute-bags but in the glass vials the quality was not satisfactory after the experiment. This study reveals that ascorbic acid and acetic acid may by considered as chemical protectants against *S. oryzae* by impregnating the storing bags; spraying at an interval of two months of the jute-bags with the compounds can protect the grains further for a longer period and the process is very economic, non-hazardous and causes negligible damage to the environment. It seems that the compounds initially act as repellants for the insects as large number of weevils did not enter into the bag. Insects entering into the bags pick up effective doses of the chemicals due to prolonged contact and thus disturbances in the physiological process is ensured resulting in mortality and failure of reproduction. As far as we know this report is the first of its kind with these compounds and it reveals that grain protection is possible without using toxic chemicals directly on the grains.

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NOTES ON TWO CARABID (CARABIDAE : COLEOPTERA) PREDATORS OF *NEPHANTIS SERINOPA* MEYRICK (XYLORICTIDAE : LEPIDOPTERA) FROM KERALA

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Short descriptions of the life history, reproduction and predatory behaviour of two beetles, viz., *Parena nigrelineata* Chaud. and *Calleida splendidula* (F.), which are predators on the coconut caterpillar, *Nephantis serinopa* Meyrick are given.

(*Key words:* adult description, life-history, predatory behaviour, *Parena nigrolineata, Calleida splendidula, Nephantis serinopa*).

The two carabid beetles, *Parena nigrolineata* and *Calleida splendidula*, the bionomics of which is briefly described in this paper, were obtained from collections of *Nephantis serinopa* infested coconut fronds from different places of Kerala. They are arboreal, and predaceous on the larvae and pupae of *N. serinopa*, in contrast to the majority of carabids which are ground inhabitants.

Parena nigrolineata chaud.

Host records of *Parena nigrolineata* in India include *N. serinopa* Meyr , *Hyblaea puera* Cramer, *Sylepta derogata* Fabr., *Nephopteryx rhodobasalis* Hamps., *Pyrausta machaeralis* Walk. and *Atteva fabriciella* Swed. Some of the biological features of *P. nigrolineata* have been given by Vasantharaj David *et al.* (1975) under the name of *P. laticincta.*

Life history

Total duration of the life cycle of this predator could not be determined as the adults did not oviposit in the laboratory. Vasantharaj David *et al.* (1975) observed that females lay eggs singly near the edges of the galleries of *N. serinopa* larvae and fasten them to the surface of the leaflet. The egg is oval, cream coloured and measures 0.65 × 1.1 mm. A female lays from 25 to 63 eggs during the course of 42 to 50 days. The larva is compodeiform. It bears sensory hairs on the dorsal and lateral sides of the body. The pupal period lasts for 5 to 7 days.

Mating behaviour

The male moves towards the female, slowly vibrating his antennae. Mounting usually occurs shortly after the male contacts the female. After mounting on the female the male holds the female at the anterior edge of the elytra with his prothoracic legs and clasps the lateral edges of the elytra with his mesothoracic legs. The mesothoracic legs are either placed on the substratum or on the lateral sides of the elytra. They remain in the paired position for 1.5 to 2 hours.

Predatory behaviour

In addition to *N. serinopa*, the larvae of *Corcyra cephalonica* Staint. and *Spodoptera mauritia* Boisd. were devoured by the larvae and adults of *P. nigrolineata*

Their mandibles are of the grasping type, being very sharp which act as cutting plates. While feeding, the prey is held between the mandibles; a wound is made through which the body juice of the larva flows through the mandibular channel into the mouth. The adults live for 2-3 months, consuming 2-3 larvae in a week.

Calleida splendidula (F.)

Calleida splendidula (=*Parena laticincta*) is reported as a predator of *N. serinopa* by Rao (1924). It is a polyphagous predator which is widely distributed in the oriental region. Gardner (1927) described the larvae of *C. splendidula* and mentioned that this is predaceous on *Pyrausta machaeralis* Walker and *Hyblaea puera* Cramer. Andrewes (1933) points out that in addition to the above two preys, *C. splendidula* is predaceous on *Nephopteryx rhodobasalis* Hampson and *Pyrausta coclesalis* Walker.

Life history

The adult females did not oviposit in the laboratory. The larvae collected from the infested leaves were completely black except the head which is brownish in colour. The larva has two long anal cerci. The whole body bears sensory hairs. The pupa is pale yellow in colour on the same day of pupation, with a black stripe on the dorsal side extending from the 2nd abdominal segment to the last abdominal segment. The pupal period lasts for $4\frac{1}{2}$ to 5 days.

Predatory behaviour

As in *Parena nigrolineata*, *C. splendidula* is predaceous both in the larval and adult stage. The feeding habits are mostly the same as that of *P. nigrolineata*. The larvae and adults were given *C. cephalonica* larvae in addition to *N. serinopa* for predation.

Among coleopterans the coccinellids and carabids have produced satisfactory results in biological control importation projects in a number of cases (DeBach, 1974). The carabid beetle *Calosoma sycophanta* had been imported in large numbers from Europe into N. America to control the gypsy moth and brown tail moth (Burgess, 1911). Carabid adults are mostly ground dwellers, but *P. nigrolineata* and *C. splendidula* are arboreal in habit as many species of the genera *Calosoma* and *Lebia*, which attack foliage feeding insects. Erwin *et al.* (1976) showed that *Eurycoelus macularis* Chevrolat (Carabidae : Lebiini) accelerates wood decay process in contrast to other ground beetles such as *Morion* spp. and *Cretacerus* spp. which act as delaying agents in the wood decay process by preying on wood boring insects. *Lebia scapularis* Fourc is reported to lead a parasitic life (Silvestry, 1904), the adult beetles feed upon all immature stages of the elm-leaf beetle *Galerucella luteola* Mull., whereas the larvae attack the pupae only. Another carabid *Arsinoe grandis* Per. represents a transitional phase between predatism and parasitism (Blair, 1927). The larva of *Arsinoe* attaches itself by the mandibles to the dorsum of the abdomen of its host, *Catamerus revoilli* Fairm, a lichen-feeding tenebrionid beetle. Both *P. nigrolineata* and *C. splendidula* are predatory in the larval and adult stages. In *Lebia* the first and second instar larvae differ in morphology, the first instar larva is elongate and has two anal cerci while the second instar larva is grublike. The larvae of *Parena* and *Calleida* are morphologically similar throughout the larval stages; their pupae are naked.

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STOCHASTIC MODEL APPROACH FOR STUDYING THE LIFE-CYCLE OF INSECTS

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A stochastic model was used to study the life-cycle of insects. The four distinct stages, *viz.*, egg, larva, pupa and adult were considered as the four states of a Markov chain. The life-cycle of *Pericallia ricini* Fb (Arctiidae) was evaluated by assuming a Markov chain model. The expected first passage time Q_{jk} was found to be an egg period of 4 days, larval period of 20 days and pupal period of 13 days for the moth. Total life-cycle from egg to adult took about 37 days.

(Key words: stochastic model, Markov chain, transition probability, first passage time, *Pericallia ricini* Fb)

INTRODUCTION

Stochastic models are being used to investigate phenomena that are concerned with a flow of events in time, especially those exhibiting such characteristics as birth, death, transformation, evolution etc. Consider a system that is capable of being in a number of states which we shall denote by $E_1, E_2, \ldots\ldots\ldots\ldots$. For each time n, we define a discrete random variable X_n whose value indicates the state of the system; that is, the event '$X_n = E_j$' is the same as the event, 'the system is in state E_j at time n'. In the population growth models, for example, the state of the system is the population size and X_n has an infinite number of possible values.

Denote by P_{jk} (n—1, n), the one-step conditional (transition) probability that the system is in state E_k at time n, given that it was in state E_j at time n—1. The characteristic Markov property is that the future probability behaviour of the system is uniquely determined once the state of the system at the present stage is given. If the system (X_n) satisfies the Markov property, then the system is called a Markov chain. An important class of chains is that for which the transition probabilities P_{jk} (n—1, n) are independent of n. We then have a homogeneous Markov chain and in such cases the (one-step) transition probabilities are denoted by $P_{jk}^{(1)} = P_{jk}$. The order of the subscripts in P_{jk} corresponds to the direction of the transition, that is, E_j to E_k.

The transition probabilities P_{jk} are written in matrix form $P = (P_{jk})$. This matrix is called the transition probability (stochastic) matrix associated with the Markov chain and will be of finite or infinite order, depending on the number of states involved. The elements in a stochastic matrix will all be non-negative and the rows all sum to unity. For homogeneous Markov chains, the m-step transition probabilities, P_{jk} (n, n+m), denoted by $P_{jk}^{(m)}$, are given by the $(J, k)^{th}$ element in the m^{th} power of the transition matrix P.

Many problems arising in practice can be reduced to a problem on first passage times in a Markov chain. ASAN *et al.* (1981) analysed the weekly body weights with the help of a three-state Markov chain model and evaluated the effect of feeding dried poultry manure for broilers. The occurrence of rainfall in Raipur district was studied by BHARGAVA *et al.* (1973) using a Markov chain model.

In this paper a stochastic model is made use of for studying the life-cycle of insects.

MATERIALS AND METHODS

A female moth of black hairy caterpillar (*Pericallia ricini* Fb (Arctiidae)) was collected from the field and it was enclosed in a cylinderical glass jar (6 × 16cm) and fresh castor leaf was provided for egg laying. 100 eggs were separated out from the egg mass laid by the moth. These eggs were kept for hatching in a cylinderical glass jar covered with muslin cloth. The first instar larvae were transferred and reared individually in glass jars. Fresh castor leaves were provided everyday throughout the larval period. Pupation took place in the cocoon on the side walls of the bottles or on the muslin clothes used for covering the jars. These bottles were kept undisturbed till adult emergence.

The four distinct stages of the moth, viz., egg(E), larva(L), pupa(P) and adult(A) were considered as the four states of a Markov chain. Each moth was in one among these states during the period of study. Observations on the egg, larval and pupal periods of individual moth were recroded at 24 hour intervals. Mortality was also recorded every day. A total number of 12 moths were lost at different stages due to natural mortality and they were excluded from the present study. The sequence E, E, E, E, L, L,……,L, P, P,……, P,A was a typical observation for a moth, covering a period of about 40 days.

RESULTS AND DISCUSSION

Transition Probabilities and Expected First Passage Times:

TABLE 1. Transition Probabilities P_{jk}.

State: j	k			
	egg	larva	pupa	adult
egg	0.75000	0.25000	0.0	0.0
larva	0.0	0.95053	0.04947	0.0
pupa	0.0	0.0	0.92453	0.07547
adult	0.0	0.0	0.0	1.0

TABLE 2. Expected first Passage times Q_{jk}

State: j to k	Number of days		
	Range	Mean (SE)	Expected first passage time, Q_{jk}
egg to larva	4	4	4.00
larva to pupa	19—22	20.22 (0.07)	20.19
pupa to adult	11—15	13.25 (0.08)	13.24

Denote by n_{jk}, the number of moths transferred from state E_j to E_k during the period of 24 hours, where E_j and E_k can be either the stages, egg, larva, pupa or adult. The one-step (unit of time being one day) transition probabilities P_{jk} were then estimated by $n_{jk}/n_{j.}$, where $n_{j.} = \sum_k n_{jk}$ and are given in Table 1.

Suppose $f_{jk}^{(n)}$ be the probability that starting from state E_j the first passage to state E_k occurs precisely at n^{th} day. Then $f_{jk}^{(n)}$ can be computed recursively from the formula (FELLER, 1972),

$$P_{jk}^{(n)} = \sum_{m=1}^{n} f_{jk}^{(m)} \; P_{kk}^{(n-m)},$$

with $P_{kk}^{(0)} = 1$.

The expected first passage times Q_{jk} from state E_j to state E_k equals

$$\lim_{N\to\infty} Q_{jk}^{(N)}, \text{ where } Q_{jk}^{(N)} = \sum_{n=1}^{N} n f_{jk}^{(n)}.$$

The convergence criterion was set to three digit accuracy after the decimal point and the expected first passage times Q_{EL}, Q_{LP} and Q_{PA} were computed. Table 2 gives the observed duration of transition (range, mean and standard error (SE) and expected first passage times Q_{jk}.

The observed duration of transitions from E to L (egg period), L to P (larval period) and P to A (pupal period) were respectively 4 days, 19 to 22 days and 11 to 15 days, coinciding with those reported by NAIR (1978), except for larval period which ranged from 26 to 32 days. The lesser range for larval period noticed in the present study may be due to seasonal variation. The expected first passage times Q_{jk} were 4 days (egg period), 20 days (larval period) and 13 days (pupal period), agreeing with their mean values. The total life-cycle from egg to adult was computed to about 37 days.

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ANATOMICAL AND HISTOLOGICAL CHANGES IN THE PROTHORACIC GLANDS OF THE LEMON-BUTTERFLY, *PAPILIO DEMOLEUS* L. (LEPIDOPTERA) DURING THE LARVAL-PUPAL-ADULT DEVELOPMENT

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The anatomy and histology of the prothoracic glands of the lemon-butterfly were studied during the larval-pupal-adult development. The glands are a pair of compact triradiate organs innervated by several nerves arising from the anterior section of the ventral nerve cord and remaining morphologically asymmetrical on the two sides throughout the development. Inactive, active and regressive stages of the glands are histologically discernible. Based on histological criteria, the glands are most active on day 4 both in the last (5th) instar larva and pupa and regress completely on day 1 of the adult stage possibly by cytolysis followed by haemocytic phagocytosis.

(*Key words:* prothoracic glands, anatomy, histology, regression)

INTRODUCTION

The prothoracic glands (PTG) are important endocrine organs that regulate moulting in insects through their hormone, ecdysone (reviews: WIGGLESWORTH, 1964; NOVAK, 1975). While a number of papers have appeared on the morphology, histology and innervation of the lepidopterous PTG (LEE, 1948; KAISER, 1949; REHM, 1951, HERMAN & GILBERT, 1966; HERMAN, 1967; SRIVASTAVA & SINGH, 1968; HINTZE-PODUFAL, 1970; YIN & CHIPPENDALE, 1973; MALA *et al.*, 1974; SINGH, 1975; SRIVASTAVA *et al.*, 1977; SEN & GANGRADE, 1977; GRANGER, 1978; SINGH & SEHNAL, 1979; WOLBERT, 1979), only a few workers have studied histological changes in relation to secretory activity (YASHIKA & YOSHIZAKI, 1967; TAKEDA, 1976; SINGH & AWASTHI, 1980, 1981) and fewer still, in relation to regression of the glands (ICHIKAWA *et al.*, 1955; HERMAN & GILBERT, 1966). This apart, none of the above studies have been carried out at short regular intervals possibly on account of the longer life cycles due to the diapausing nature of the insects, largely moths, that have been investigated in this respect. This has made comprehension of the temporal events more difficult. The present paper includes observations on the histological and regressive changes in the PTG of a species of insect (butterfly) whose shorter instar duration makes it a particularly suitable material for the studies of this kind.

MATERIALS AND METHODS

Different larval instars of the lemon-butterfly were collected from the lemon nurseries and reared on lemon leaves in the laboratory. For the study of histological changes in the PTG during the premoult, intermoult and metamor-

phosis, the glands of the late 4th and 5th (ultimate) instar larvae, pupae and adults were dissected in insect Ringer (EPHRUSSI & BEADLE, 1936) and fixed in Bouin's fluid— those of the 4th instar larvae, immediately before moult, of the 5th instar larvae and pupae which have 5 and 6 days instar duration respectively, at 24 hr interval and of the adults soon after emergence (day 0) and day 2. Whole mounts were stained in haematoxylin and sections cut at 5 μm were double stained in haematoxylin and eosin. Camera lucida diagrams of the PTG were drawn from the dissections and the cell size was measured with the help of stage and ocular micrometers.

OBSERVATIONS

Anatomy of the PTG

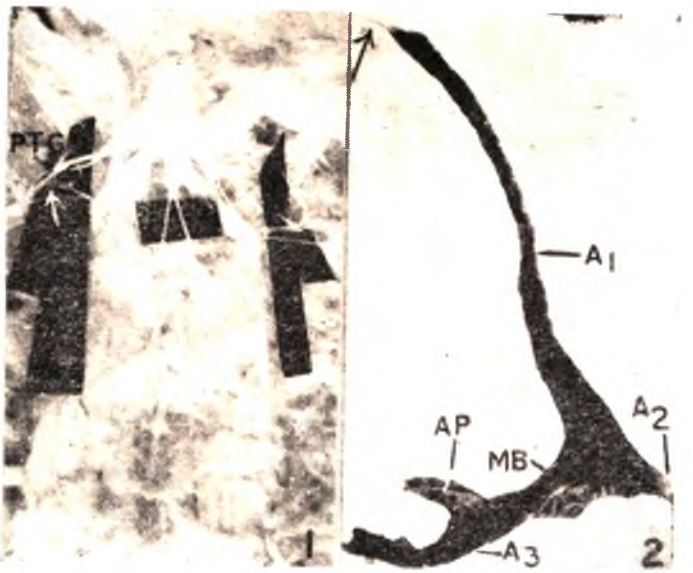
Each of the paired PTG of the larva (Fig. 1) is located on a tracheal trunk close to the first thoracic spiracle. The glands have a well defined triradiate form with long occasionally bifid anterior limb and two short postero-lateral limbs arising from a relatively broader main body (Fig. 2). The postero-lateral limbs may have additional processes. While the main body and postero-lateral limbs lie on the dorsal surface of the tracheal trunk closest to the spiracle, the anterior limb runs somewhat dorso-laterally getting off the tracheal trunk terminally. The glands are closely invested by a thin acellular sheath membrane whose prolongations beyond the extremities of the limbs provide insertions to the glands. The anterior limb is inserted on the cervical membrane between the head and the prothorax and the postero-lateral limbs on the venter (larval sternite) between the pro- and mesothorax. The additional processes of the limbs are devoid of insertions. The main body of the glands sometimes bear 1-2 cell-less areas covered by the sheath membrane alone. The PTG of the two sides of an individual or of two different individuals even of the same age remain morpholgoically asymmetrical throughout the (larval) development (Fig. 3) and are never identical as the bilateral organs are normally prone to be in animals. Each PTG in this insect is innervated by 5 nerves (one each from the suboesophageal ganglion, first and second interganglionic connectives and two from the prothoracic ganglion) arising from the anterior section of the ventral nerve cord. One such nerve can be seen to enter the gland on the left side in Fig. 1 (for the Fig. and details of innervation, see SRIVASTAVA *et al.*, 1977).

The gland cells

The PTG are one-cell thick with their cells arranged in rows. The number of rows varies according to the width of the limbs. The anterior limb, for instance, may distally start with 2-3 rows becoming 1 in the middle region and increasing again to 4-8 as the limb joins the main body. The postero-lateral limbs and their additional processes may be 1-3 row thick depending on their width. The gland cells are angular in the early stages of the larva, their broad and narrow ends alternating to give the glands a close-set arrangement. In the main body, however, the cells are more spaced, the spacings getting more pronounced in the later stages of the development. The shape of the gland cells continuously change from angular to elongated to oval to spherical during the course of development and the size of the glands also diminish with age. The total number of cells in each PTG averages between 150-200 in the mature 5th instar larva.

Histological changes in the larval glands

Like morphology, histology of all the gland cells of both the glands of the same individual or of two different individuals of the same age is not always identical. Conclusions in regard to histological features reported below were, therefore, drawn



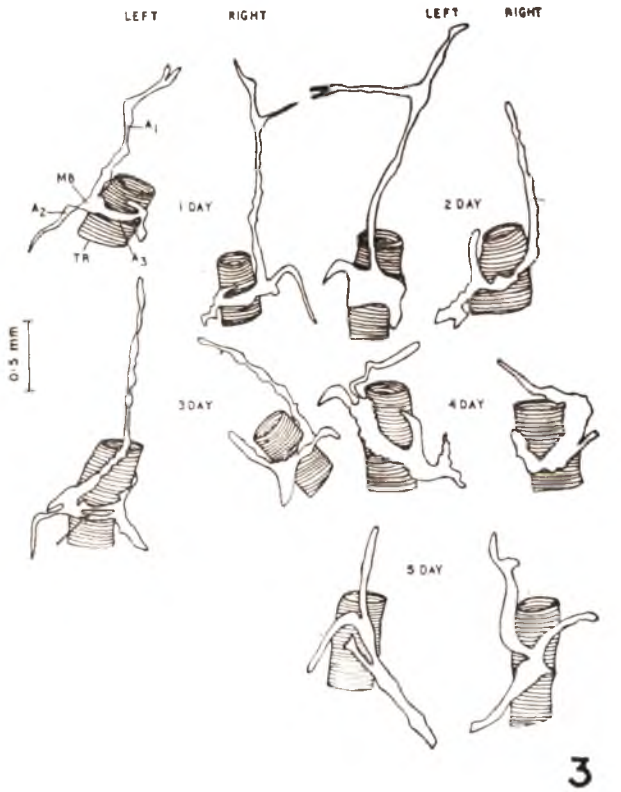


Fig. 1. Full grown 5th instar larva dissected to show the PTG *in situ* and one of the innervating nerves (arrow) × 40. Fig. 2. W. M. of the PTG showing its anterior (A_1) and postero-lateral (A_2, A_3) limbs, additional processes (AP), main body (MB) and a sheath membrane prolongation for insertion (arrow). Haematoxylne, × 100. Fig. 3. Camera lucida drawings showing morphological asymmetry in the PTG of the two sides during the 5th instar larva. TR, tracheal trunk, arrow points to a cell-free area; remaining letterings same as in Fig. 2.

TABLE 1. PTG cell size and area during the larval and pupal stages in *Papilio demoleus.*

Stage	cell size[1] (μm)	cell area (μm^2)
Late 4th instar larva	31.5 ×27.3	859.95
5th instar larva:		
day 0	32.5 ×29.1	945.75
day 1	40.33×29.6	1193.77
day 2	40.71×30.1	1225.37
day 3	40.8 ×32.4	1321.92
day 4	38.2 ×34.9	1333.18
day 5 (prepupa)	39.6 ×32.2	1275.12
Pupa :		
day 0	33.33×30.75	1024.89
day 1	36.4 ×31.8	1157.52
day 2	37.9 ×30.6	1159.74
day 3	37.1 ×31.5	1168.65
day 4	39.5 ×30.2	1195.92
day 5	40.8 ×26.0	1060.80

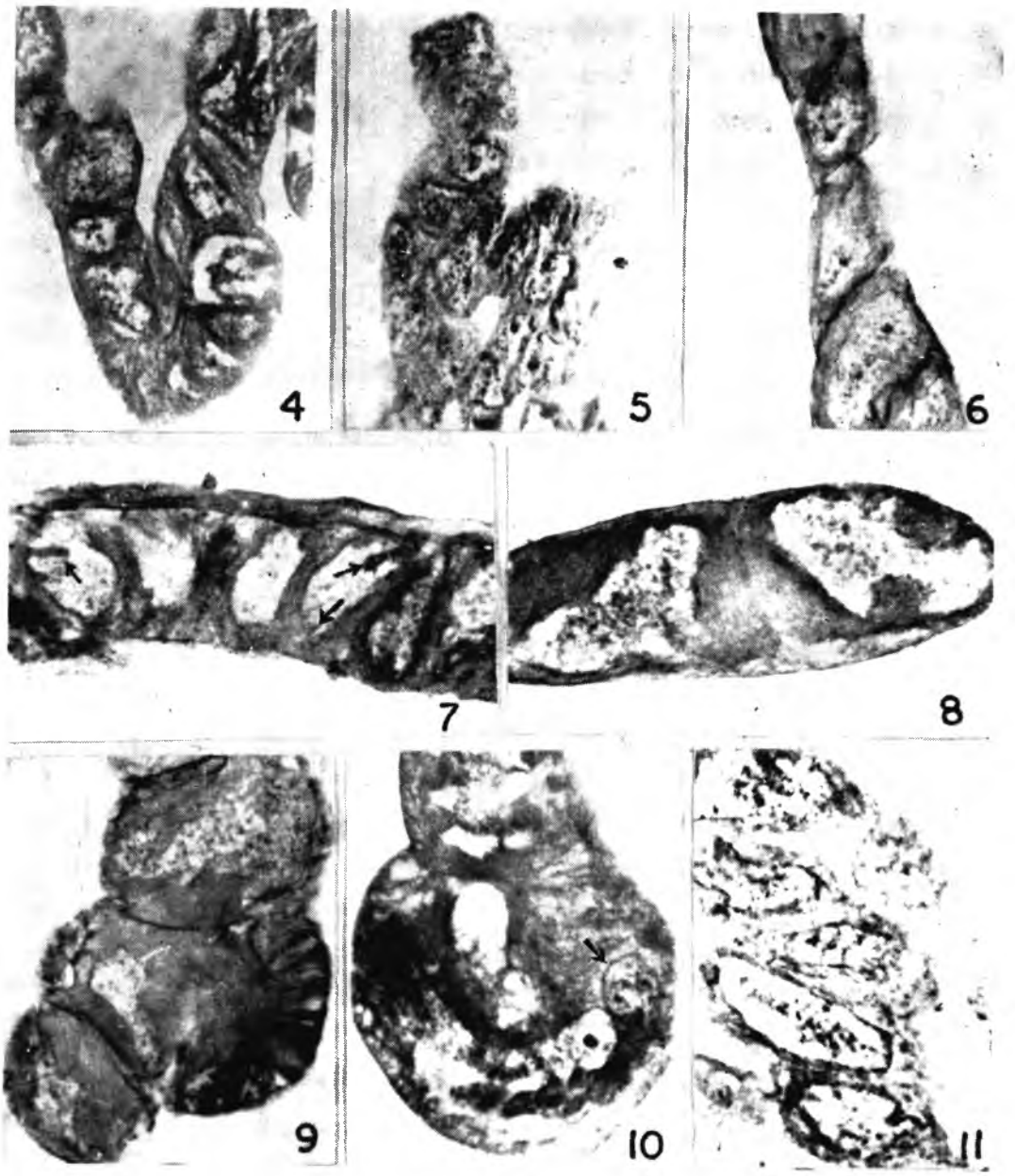
[1]average of 10 cells

only when majority of the gland cells showed similar features.

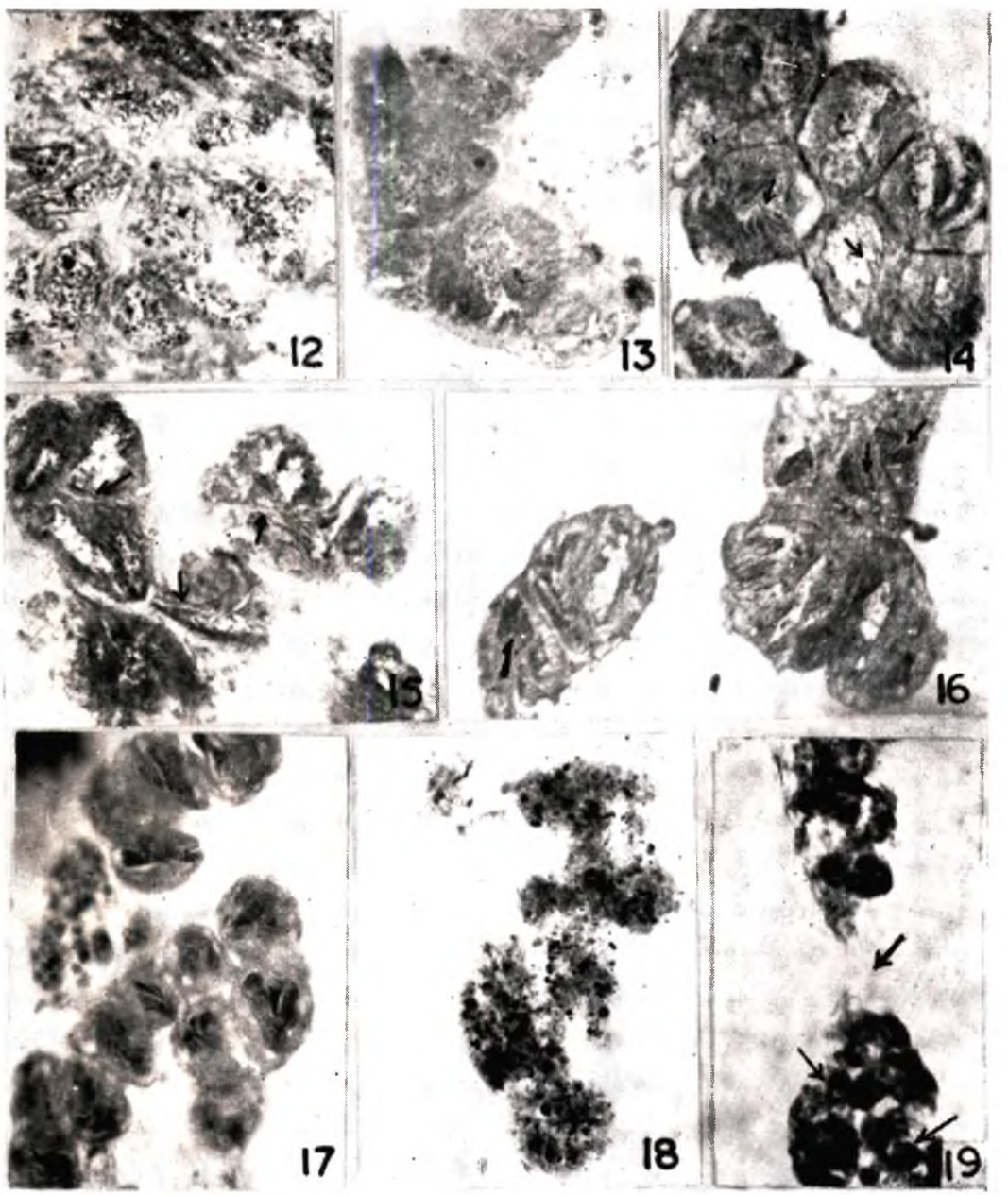
The gland cells of the late 4th instar larvae (Fig. 4) show scanty cytoplasm, regular nuclear boundary and chromatin largely concentrated in the middle of the nuclei. In 0 day (newly moulted) 5th instar larvae (Fig. 5), there is some increase in the cell size (Table 1), chromatin disperses uniformly to fill the nuclei and nucleoli become prominently visible. On day 1 (Fig. 6), there is a perceptible augmentation in the cytoplasm and the nuclei still showing prominent nucleoli, dispersed chromatin and regular nuclear boundary. On day 2 (Fig. 7), the cytoplasm pushes (invaginates) into the nucleus at places obviously due to further increase in its volume. On day 3 (Fig. 8), the cytoplasm increases still further though not equally on all sides and its invaginations enlarge to give the nuclei a somewhat irregular boundary. On day 4 (Fig. 9), there is a maximum increase in the cell size with the cytoplasm developing a large number of vacuoles on the periphery and the nuclei becoming relatively smaller but with an irregular boundary. In some of the cells, occasional inclusions are encountered in the cytoplasm (Fig. 10). On day 5 (prepupal stage, Fig. 11), the cells return to the late 4th instar stage with scanty cytoplasm, regular nuclear boundary and chromatin concentrated in the middle of the nuclei.

Histological changes in the pupal glands

As in the larval stage, the gland cells of the 0 day pupa (Fig. 12) also show little cytoplasm and regular nuclear boundary with dispersed chromatin and prominent nucleoli. On day 1 (Fig. 13), the cell size increases, nuclear features remain unchanged but the nuclear boundary is not so regular. On day 2 (Fig. 14), there is further increase in the cell size with



Figs. 4—11. Larval PTG cells in section stained in haematoxylin and eosin. Fig. 4. Late 4th instar larva. Figs. 5—11. Fifth instar larvae of 0—5 days. Mark cytoplasmic invaginations (arrows) pushing into the nucleus in Fig. 7 and cytoplasmic inclusion (arrow) in Fig. 10. For details, see text. Magnification of Figs. 1—7, × 315 and of Figs. 8—11, × 675.



Figs. 12—17. Pupal PTG cells in section between 0—5 days. Mark striations (arrows) radiating from nucleus in Fig. 14. nuclar constrictions (thin arrows) and fragments (thick arrow) in Fig. 16. and nuclear pycnosis and/rampant fragmentation accompanied by cytoplasmic vacuolation in the regressing cells in Fig. 17. For details see text. Magnification for all Figs., × 315. Fig. 18. W. M. of the regressing PTG in 6 day pupa showing chromatin blobs and somewhat foamy (non-cellular) look of the glands. Haematoxylin, × 150. Fig. 19. Section of the PTG of 1 day adult showing invading haemocytes (thin arrows) and persisting sheath membrane (thick arrow). × 675.

many cells showing striations in the cytoplasm radiating from the nuclear margin. On day 3 (Fig. 15), the striations become longer reaching almost up to the cell periphery. On day 4 (Fig. 16), there is a maximum enlargement in the cell size with vacuoles appearing on the periphery of the cytoplasm. The nuclei become smaller and show constrictions leading to nuclear fragmentation in some cells. On day 5 (Fig. 17), there occurs a reduction in the cell size but prominent cytoplasmic vacuoles continue to be present. Nuclear fragmentation which commenced on the preceding day spreads throughout the gland and the fragments looking pycnotic. On day 6 (Fig. 18), the last day of the pupal stage, cellular appearance of the glands is completely lost and deeply staining chromatin blobs are seen scattered throughout the glandular tissue which presents a foamy look in whole mounts. In 0 day adult (Fig. 19), the glands become greatly reduced and very difficult to locate due to a heavy deposition of fat body and loss or modification of the tracheal trunks that had so far supported the glands and had acted as landmarks for their location. The glands by now appear full of haemocytes intermixed with nuclear fragments and with the sheath membrane still visible. On day 2, the glands are no more traceable indicating that they were lost sometime during the later part of day 1.

DISCUSSION

Anatomical changes

HERMAN & GILBERT (1966) and JOLLY (1968) in their classification of the PTG have placed lepidopterous glands in the category of diffused type. This does not seem to be correct since in a large number of Lepidodtera studied so far, the PTG have been found to be compact organs with a well defined form (LEE, 1948; SRIVASTAVA & SINGH, 1968; HINTZE-PODUFAL, 1970; KARLINSKY & SRIHARI, 1978; MALA *et al*, 1974). LEE (1948) recognised two types of PTG; band type and bead type within Lepidoptera. As we mentioned earlier, the gland cells constantly undergo changes in their size and shape apparently due to their changing physiological state. As such, the shape of the glands should reflect their physiological state rather than represent gland types. These changes should also be the cause of the cyclical fluctuations in the size of the glands as observed by KARLINSKY & SRIHARI (1973) and if not identical in both the glands of an insect, should again be the cause of the morphological asymmetries that is observed in the present insect. WILLIAM'S (1948) observation on the syncytial nature of these glands in *Hyalophora cecropia* has been contradicted in the same species by HERMAN & GILBERT (1966). Subsequent studies in different lepidopterous species have now confirmed the cellular nature of the glands. Further' it is interesting to note that the number of cells in the PTG is greatly variable in different lepidopterous species investigated. For instance, it has been found to be 30 in *Ephestia cautella* (ICHIKAWA *et al.*, 1955), 203-287 in *Hyalophora cecropia* (HERMAN & GILBERT, 1966), 55 in *Galleria mellonella* (MALA *et al.*, 1974), 51-62 in *Spodoptera litura* (SEN & GANGRADE, 1977), 194 in *Philosamia ricini* (SINGH & AWASTHI, 1980), 73 in *Achoea janata* (SINGH & AWASTHI, 1981) and 150-200 in the present insect. The above figures in *Hyalophora* have been given for the male pupa and in the rest, for the last larval instar. From their observations in *Hyalophora* and two other moths, HERMAN & GILBERT (1966) concluded that PTG cell size is related to the size of the insect,

larger insects having larger gland cells. This correlation was further demonstrated in *Bombyx mori* in which larger females were shown to contain greater amounts of ecdysone as compared to smaller males (SHAAYA & KARLSON, 1965). It is therefore, quite probable that like the cell size, cell number of the PTG may also be related to the size of the species, in other words to the bulk of the tissues needing ecdysone treatment. This speculation, however, needs to be given a firmer ground by a correlative study of the body and gland sizes in different species of insects.

Innervation of the PTG

Innervation of the PTG in Lepidoptera has been reported by almost all the workers studying this aspect (LEE, 1948; HERMAN & GILBERT, 1966; SRIVASTAVA & SINGH, 1968; HINTZE-PODUFAL, 1970; YIN & CHIPPENDALE, 1973; SINGH, 1975; SRIVASTAVA *et al.*, 1977; GRANGER, 1978; SINGH & SEHNAL, 1979; SINGH & AWASTHI, 1980, 1981). A notable difference between the innervation-pattern reported for moths and that observed in the present insect lies in the fact that in the former, the PTG have been shown to be innervated by 4 (suboesophageal, prothoracic, mesothoracic and metathoracic) ganglia (HERMAN & GILBERT, 1966; SINGH & AWASTHI, 1980) or at least by the first three (LEE, 1948; SINGH, 1975; SINGH & SEHNAL, 1979; SINGH & AWASTHI, 1981): in the latter, only the first two ganglia are involved (SRIVASTAVA *et al.*, 1977). This seems to be due to the diffused and therefore, more scattered nature of the gland cells in the moths. SINGH & AWASTHI (1980, 1981) have not reported any nerve from the interganglionic connectives innervating the PTG which other workers have done (LEE, 1948; HERMAN & GILBERT, 1966; SRIVASTAVA, SINGH & AWASTHI (1980, 1981) have also shown the nerves ending up in the PTG which gives an impression that the nerves are exclusively meant for the glands when actually, the nerves send only minor branches to the glands, their main trunks extending beyond them to innervate the muscles, spiracles and other target organs of this region.

The significance of the PTG innervation is as yet not well understood. Some workers detecting stainable neurosecretory material (ARVY & GABE, 1953; SRIVASTAVA & SINGH, 1968) or elementary electron dense (neurosecretory) particles (SCHARRER, 1964; NORMAN, 1965; BEAULATON, 1968; HINTZE-PODUFAL, 1970) in the innervating nerves suspect a direct hormonal control on the glands, others believe that the suboesophageal ganglion (ALEXANDER, 1970) or the pro- and mesothoracic ganglia and by inference, their nerves wield an inhibitory influence over the glands (MALA *et al.*, 1977), while still others (SRIVASTAVA *et al.*, 1977) failing to observe any adverse effect after sectioning all the PTG nerves on growth and metamorphosis of the insect are inclined to believe that the nerves alone do not regulate the activity of the glands. These varying results only go to show that the whole question of regulation of the PTG activity is more complex involving several factors than what is presently understood.

Histological changes

1. In relation to secretory activity

Most workers studying secretory activity of the PTG agree that little cytoplasm, lack of cytoplasmic vacuoles and regular nuclear boundary indicate inactive glands cells and more cytoplasm, presence of cytoplasmic vacuoles and irregular nuclear

boundary, active ones (ICHIKAWA *et al.*, 1955; HERMAN & GILBERT, 1966; TAKEDA, 1976). Based on these criteria, the PTG in the present insect should be least active immediately before moults (in the late 4th instar larva and perpupa) and most active on day 4 both in the larva and pupa when the glands are maximally endowed with histological features that depict these states. Even though, irregularity of the nuclear boundary has been regarded as an important sign of glandular activity, it is, as observed as in these studies, is caused by cytoplasmic enlargement and by itself cannot be the cause of activity. In regard to the actual synthesis of the hormone, ecdysone, it is difficult to make any positive comments on the basis of the present studies employing routine histological techniques. However, since many workers have reported RNA synthesis in the PTG during early stages of glandular activity and have associated it with ecdysone synthesis (OBLERLANDER *et al.*, 1965; HERMAN & GILBERT 1966; TAKEDA, 1976), the appearance of prominent nucleoli, the sites of RNA synthesis (DE-ROBERTIS *et al.*, 1965) in the early stages of both larva and pupa followed by a great enlargement of cytoplasm in the present insect can be taken to indicate synthesis of some kind of proteins, possibly enzymes that may be finally needed for the synthesis of ecdysone itself. Cytoplasmic vacuoles that follow cytoplasmic enlargement seem to be the storage sites for the hormone which being a steroid is likely to be removed by solvent treatment of the sections leaving empty spaces. Since the cell size (cytoplasmic area) and number of vacuoles are maximum on day 4 of the larval and pupal stages, the glands seem to be most active on this day in both the stages. Presence of granules (ICHIKAWA *et al.*, 1955) or vacuoles in the nuclei (BOISSON, 1952; WELLS, 1954; HERMAN & GILBERT, 1966; SINGH & AWASTHI, 1980) that led these workers to believe that nucleus is the site of synthesis of ecdysone or its precursor are not seen in the PTG of the present insect and, therefore, we believe that the cytoplasm which undergoes a profound change is the actual site for hormone synthesis.

2. In relation to glandular regression

Regression of the PTG becomes inevitable once they are exposed to a juvenile hormone (JH) free environment prior to imaginal moult (WIGGLESWORTH, 1955; HERMAN & GILBERT, 1966). In the present insect, this (JH free) period should coincide with day 5 of the pupal stage when regressive changes (nuclear pycnosis and fragmentation) become clearly manifest in the histology of the gland cells. Histological changes such as nuclear fragmentation, pycnosis, chromatin breakdown, loss of cellular appearance and presence of cytoplasmic vacuoles which have been generally accepted as features of glandular regression are all observed in the present insect. The gland cells are believed to be cytolysed by their own enzymes, presumably lysosomal in origin (Scharrer, 1966). As such, the cytoplasmic vacuoles observed in the regressing cells in day 5 pupa should represent autophagic vacuoles within which the enzymes may be functioning. Invasion of the PTG by haemocytes only near the terminal stages of regression, also reported by HERMAN & GILBERT (1966) in *Hyalophora cecropia* and SCHARRER (1966) in cockroaches, support cytolytic dissolution of the gland and their own role at this (late) stage would thus be restricted to the removal of the glandular debris by phagocytosis. The sheath membrane which HERMAN & GILBERT (1966) find breaking down as

early as on day 6 of the adult development, is seen to last till the end of metamorphosis in this insect. However, our observation in regard to the loss of the PTG some time during the later part of day 1 of the adult stage is in agreement with that of these authors.

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STUDIES ON THE ERIOPHYID MITES (ACARINA : ERIOPHYOIDEA) OF INDIA. XI. DESCRIPTIONS OF THREE NEW SPECIES FROM WEST BENGAL[1]

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Three new species viz., *Tegolophus gelonis* sp. nov. infesting *Gelonium multiflorum* A. Juss., *Neotegonotus bengalensis* sp. nov. infesting *Ficus bengalensis* L. and *Acalitus hibisci* sp. nov. infesting *Hibiscus vitifolius* L. have been discussed along with their distribution, host-plant relationships and their affinities with other related known species. Some photographs have been provided to show the nature of damage by 2 of the above eriophyid species.

(Key words: Acarina, eriophyids, taxonomy, new species, India)

1. Acalitus hibisci sp. nov. (Figs. IA-H)

Female: Body 117 143[2] long, 46-54 wide, worm-like, whitish in colour. Rostrum 20-23 long, moderately arched down with subapical seta 4.2 long. Shield 23-26 long, 24-36 wide, subtriangular with smller anterior lobe; shield design represents some longitudinal lines; median line distinct, present throughout the shield length; admedian lines sinuate, arched outwardly, arise from apex of the anterior shield lobe, run posteriorly and divergently upto 0.6 part, then become convergent and ultimately meet the median line near rear margin; submedian lines two; a transverse line connecting the admedians with lateral shield margin present on 0.6 part; dorsal tubercles small, divergent, 17-19 apart, situated on or near rear shield margin; dorsal seta 21-25 long. Forelegs 23-26 long from trochanter base; femur 8-10 long with a smaller seta of 5-8 long; patella 3-4 long with a seta of 19 long; tibia 4-5 long without foretibial seta; tarsus 5-7 long with two setae each 15-18 long; claw 6-8 long, without knob; feather claw simple, 5-rayed. Hindlegs 22-25 long from trochanter base; patella withot seta; tibia 3-4 long; tarsus with seta 13-16 long; claw 6-8 long; other characters as in foreleg. Anterior coxae more or less fused, with a faint median suture; hind coxae ornamented with curved lines specially around the dorsal tubercles; first coxal tubercles slightly ahead of the level of anterior coxal approximation; second coxal tubercles ahead of the level of third coxal tubercles.

Abdomen with 65-69 tergites and almost with equal number of sternites; tergites and sternites uniformly microtuberculate; microtubercles round, bead-like present on posterior ring margin. Lateral seta 16-23 long; on about sternite 10; first ventral seta 31-37 long; on about sternite 24; second ventral seta 5-8 long, on about sternite 40; third ventral seta 14-18 long, on about sternite 63; caunal

[1] Part of the thesis submitted by the first author for Ph. D. degree in the University of Kalyani.

[2] Measurements of size are in μm, unless otherwise stated.

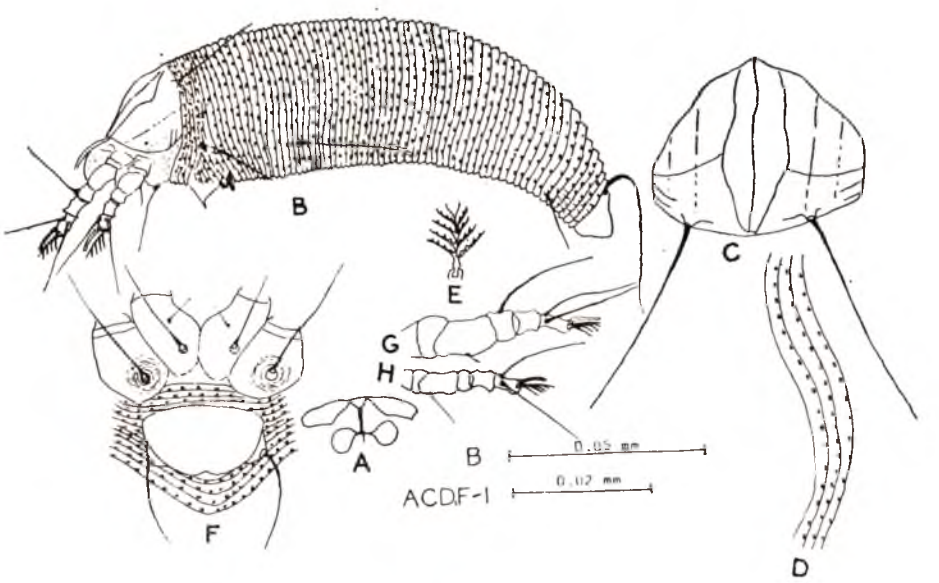

Fig. 1. *Acalitus hibisci* sp. nov., Female: A—H. A—internal female genitalia; B—lateral view of mite; C—anterior dorsum of mite; D—side view of skin structure; F—featherclaw (empodium); G—foreleg; H—second leg; I—tarsus with lower tarsal seta.

seta 47-55 long; accessory seta missing. Genitalia 13-20 wide and 7-12 long; coverflap more or less smooth, without longitudinal scorings.

Male: Unknown.

Holotype: ♀, on slide (No. 161/33/77). INDIA : WEST : BENGAL : Nadia, Kalyani, 11.xii.1977 from *Hibiscus vitifolius* L. (Malvaceae) coll. S. Chakrabarti. **Paratypes**: ♀♀, on 3 slides (Nos. 162/75/80 to 164/75/80), collected on 4.iii.1980 from the same plant and locality by S. Mondal.

Distribution: India: West Bengal.

Relation to the host plant: The mite causes compound capitate galls (Fig. 4) on both surface of leaves. The cavity of the galls are filled with hairy outgrowth and the mites are found within these hairs. Heavy infestations were noticed during May-October when galls become matured and the leaves turn yellowish and become crinkled.

Remarks: In *Acalitus* Keifer, forefemora usually without any seta or at best with a short spine while foretibia always without setae or spine. The present species can be included under the genus *Acalitus* Keifer except the setal character on forefemora. *Acalitus hibisci* sp. nov. is included under the genus *Acalitus* considering the concept that the members of this genus may or may not have forefemoral seta. Otherwise a separate genus has to be erected to accommodate the present new species.

The present species remains distinct from all the known species under this genus in having a seta on forefemora. In having 5-rayed feather claw this species shows its affinity with *Acalitus anthonii* Keifer (1972), *A. gilae* Keifer (1970), *A.*

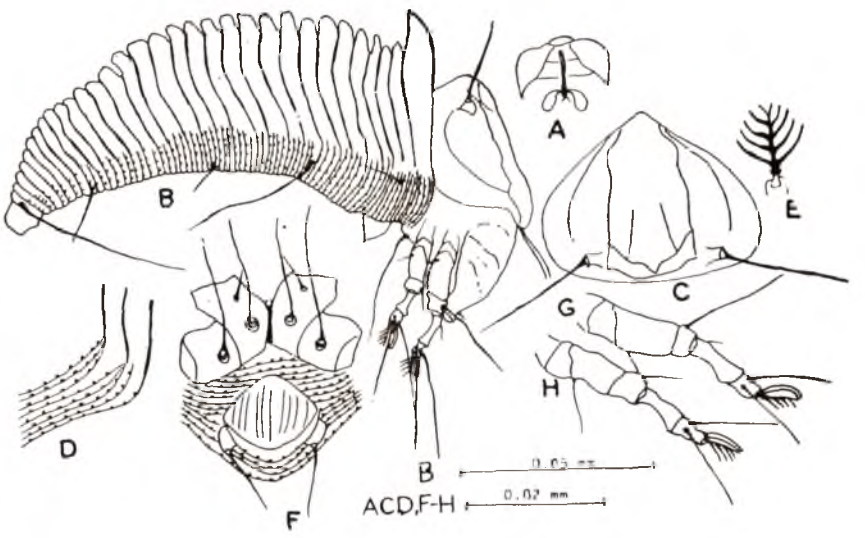

Fig. 2. *Neotegonotus indicus.* sp. nov., Female : A—H.
(For explanation to A—H, see under Fig. 1.)

ledi Keifer (1965), *A. morrisoni* Mason (1970), *A. tenuis* Manson (1970), and *A. rapaneae* Keifer (1977), but otherwise this species is a distinct one.

2. Neotegonotus indicus sp. nov. (Figs. 2A-H)

Body 157-214 long, 52-65 wide, fusiform, yellowish in colour. Rostrum 27 long; curved down; subapical seta 6 long. Shield semicircular in anterior outline, with moderately large anterior lobe over rostral base, 34-49 long and 40-50 wide; shield design not clearly discernible, but with a number of faint longitudinal lines; median line absent; admedian lines prominent on posterior 0.33 part and meet in a common point through two diagonal lines near the centre at rear margin; submedian lines at least two; first sub-median sinuate, arising from the base of anterior shield lobe, runs posteriorly straight and then converge near dorsal tubercles to meet the posterior end of admedian; second submedian runs almost parallel to lateral shield margin. Dorsal tubercles near rear shield margin and 14 apart; dorsal setae 22-31 long, directed up and laterad. Forelegs 33-35 long from trochanter base; femur 9-13 long with a seta 13-17 long; patella 4-5 long with a seta 21-23 long; tibia 9-12 long with seta 5-12 long near its base; tarsus 6-8 long with two setae, each 15-18 long; claw 7 long, moderately arched, without knob; featherclaw 5-rayed. Hindlegs 32-35 long; femur 10 long with a seta 14 long; patella 3 long with a seta 9-13 long; tibia without seta; tarsus 6 long with two setae, each 17-27 long; claw 8 long; other characters as in forelegs. Anterior coxae connate with a distinct sternal line; coxae almost without any ornamentation except around the setae; first coxal setae much ahead of anterior coxal approximation; second coxal tubercles much ahead of the transverse line across third coxal tubercles.

Abdomen with 32 tergites and 68-72 sternites; tergites strongly arched middorsally and non-microtuberculated; sternites microtuberculated, the microtubercles

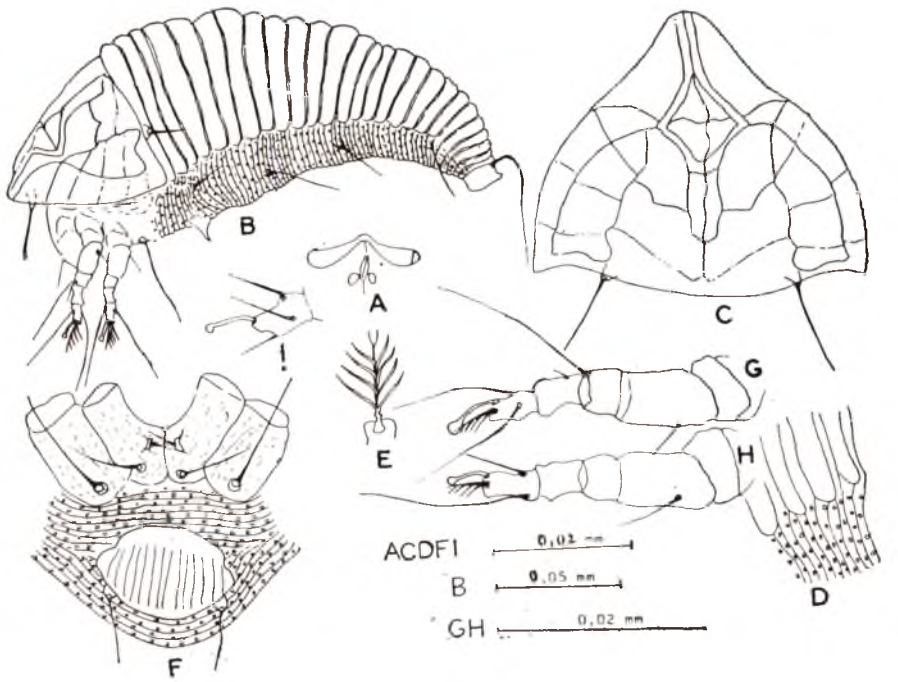

Fig. 3. *Tegolophus gelonis* sp. nov., Female : A—H.
(Explanation to A—H as in Fig. 1)

resting on rear ring margin. Lateral seta 13-16 long, on about sternite 11; first ventral seta 18-80 long, on about sternite 25; second ventral seta 12-16 long, on about sternite 44; third ventral seta 19-23 long, on about sternite, 65 caudal seta 49-73 long; accessory seta missing. Female genitalia 15-17 wide and 10-14 long; genital coverflap with about 10 longitudinal scorings; genital seta 10-14 long.

Male: Unknown.

Holotype: ♀, on slide (No. 183/2/75) INDIA : WEST BENGAL : Nadia, Kalyani, 11.v.1975 from *Ficus bengalensis* L. (Moraceae), coll. S. Mondal. **Paratypes:** ♀♀ on 4 slides (Nos. 184/2/75 to 187/2/75), collection data as in the holotype.

Distribution: India : West Bengal.

Relation to the host plant: Mites were found on ventral surface of leaves as well as on apical shoots. Due to infestation by these mites leaves and apical shoots turn deep brownish and further growth of apical shoot is stunted.

Remarks: *Neotegonotus indicus* sp. nov. differs from the only known species under the genus *Neotegonotus fastigatus* (Nalepa, 1890) in having 5-rayed featherclaw, detailed shield design and number and texture of tergites.

3. Tegelophus gelonis sp. nov. (Figs. 3A-I)

Female: Body 153-161 long, 62-70 wide; fusiform; pale yellow in colour. Rostrum 17-19 long, projecting down; subapical seta 4 long. Shield 26-30 long and 34-40 wide, subtriangular, with prominent anterior lobe; shield design represents a complicated system of cells consisting of longitudinal and transverse lines; median line almost complete but not touch the

Fig. 4. Leaf of *Hibiscus vitifolius* showing compound capitate galls induced by *Acalitus hibisci* sp. nov.

Fig. 5. Wrinkled leaves of *Gelonium multiflorum* A. Juss. caused by *Tegolophus gelonis* sp. nov.

rear margin of shield, little sinuate at middle; admedian lines originate laterally from the tip of anterior lobe, run parally backwards upto 0.25 portion of shield, then diverge upto 0.37 portion and again converge and ultimately meet the median line on 0.75 portion of shield; a cross line present on 0.37 portion and meets the median and admedians and later form an arc downwardly and posteriorly to meet rear shield margin; a longitudinal line probably submedian, present in between the arc and admedian and meet the arc anteriorly and rear shield margin posteriorly; this submedian is further connected with admedian on 0.33 part by an oblique line and with median by an oblique line near rear margin; lateral shield with a few cells (3-4); a central cell present just below the base of anterior lobe of shield. Dorsal tubercles placed on rear shield margin with setae 4-6 long, directed caudad; other details of shield design as shown in the diagram. Forelegs 44-46 long from the base of coxae; femur 10-12 long, with seta 11 long; patella 3-5 long, with seta 12-22 long; tibia 5-6 long, with foretibial seta 5-7 long; tarsus 5-8 long, with two setae, each 19-22 long, claw 5 long, with knobbed apex; featherclaw simple, 5-rayed. Hindlegs 39-41 long from the base of coxae; femoral seta 9-12 long; patella and tibia without seta; tarsus with two setae, each 16-19 long; other characters as in foreleg. Anterior coxae connate, with distinct median suture; coxae ornamented with dottod lines; first coxal tubercles below the level of anterior coxal approximation and with setae directed opposite to each

other; second coxal tubercles slightiy ahead of the transverse line connecting third coxal tubercles.

Abdomen with 25-26 tergites and 57-60 sternites; tergites with more conspicuous margins and with three distinct ridges: one mid dorsal and two subdorsal which are fading caudad; sternites with less conspicuous margins and with minute beads at margins; a last few sternites are microstriated. Lateral seta 8-11 long, on about sterinite 11; first ventral seta 32-36 long, on about sternite 24; second ventral seta 4-7 long, on about sternite 38; third ventral seta 12-15 long, on about sternite 54; caudal seta 28-41 long; accessory seta missing. Female genitalia 11-13 wide, 8 long; coverflap with about 12-14 longitudinal stripes; seta 10-12 long.

Male: Unknown.

Holotype: ♀, on slide (No. 188/77/78), INDIA : WEST BENGAL: Nadia, Nabadwip, 15.iv.1978 from *Gelonium multiflorum* A. Juss (Euphorbiaceae) coll. D. Bhattacharya. **Paratypes**: ♀♀, on 6 slides (Nos. 189/28/77 to 194/28/77), collected on 15.viii.1977 from the same plant, Birbhum, Santiniketan, coll. S. Charabarti.

Distribution: India: West Bengal.

Relation to the host plant: The mites were found in association with a member of Rhyncaphytoptidae (not yet identified) on both surfaces of leaves. Due to heavy infestation the leaves become wrinkled (Fig. 5). Maximum population of this species was observed during the months of July, August and September.

Remarks: This new species belongs to the species group having broad tergites and narrower sternites which are more numerous than the sternites. In this group, 3 species viz. *Tegolophus pfaffiae* Keifer (1963) *Tegolophus ringsi* Styer (1975) and *Tegolophus kalyanii* Chakrabarti and Mondal (Chakrabarti *et al.*, 1981) are known with 5-rayed featherclaw. However, the present species, *Tegolophus gelonis* sp. nov. differs from above three species by its complicated shield design and arrangements of first coxal setae.

All the type materials included in this paper are deposited at present in the collection of Biosystematics Research Unit, Department of Zoology, University of Kalyani.

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ON THE GENUS *THLIPSOMERUS* MARSHALL (COLEOPTERA: CURCULIONIDAE:EREMNINAE) WITH THE DESCRIPTION OF TWO NEW SPECIES AND ONE NEW GENUS

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The genus *Thlipsomerus* has been revised and two of the three species so far described have been taken out and referred to a new genus *Amrikus*. Two new species *viz.*, *nigromaculatus* and *darjeelingensis* have been described under *Thlipsomerus*. Keys to the three species of *Thlipsomerus* and *Amrikus* are also included.

(Key words: Thipsomerus, Amrikus, revision of genus)

During the course of studies on the Eremninae of this country over a period of five years, the authors examined more than 100 species including a number of new ones. The present report concerns 5 species of genus *Thlipsomerus* Mshl.

The genus *Thlipsomerus* was established by Marshall (1944) for the species *Cyrtepistomus subcosticollis* Mshl. He (Marshall, 1944) also transferred the species *Cyrtepistomus glebossus* Mshl. and *Cyphicerus deplanatus* Faust, under this genus. However while doing so, Marshall did point out the heterogenous nature of the three species referred to genus *Thlipsomerus*. The present study includes description of the male and female genitalia for the first time, which reveal that *glebossus* and *deplanatus* are not con-generic with *subcosticollis*, the type species of this genus. A new genus *Amrikus* is proposed for the two species. In addition, two additional species are being reported under genus *Thlipsomerus* Mshl. The revised characterisation of the genus *Thlipsomerus* Mshl. and keys to the species of this genus and those of the genus *Amrikus* gen. nov. have been given. The detailed description of *A. deplanatus* (Fst.), with description of the structure of the genitalia is given.

Genus Thlipsomerus Mshl.

Marshall, Ann. Mag. Nat. Hist. (11) 11, pp. 79, 89 (1944). Type species: *Cyrtepistomus glebossus* Mshl.

Head with frons wider than base of rostrum; eyes circular and somewhat convex. Rostrum somewhat longer than its basal width; epistome very short, with immediately behind it two large bare foveae; mentum with 4 setae. Antennae squamose and setose; scape gradually clavate; funicle with two basal joints variable in length. Prothorax transversely flattened, its posterior margin bisinuate, with ocular lobes well-developed. Elytra with shoulders roundly rectangular striae partly covered with scales but punctures visible; alternate intervals usually more or less raised. Legs with middle femora flattened and widened at base and also in other legs to a less extent; corbels of hind tibiae open; claws free. Aedeagus

Fig. 1. Photograph of adult *Thlipsomerus subcosticollis* (Mshl.).

bilobed at apex; exophallic valve projecting out; phallotreme with small orificial plates. Female genitalia with bursa copulatrix well-developed; spermatheca with collum lying parallel to ramus.

Type species- *Cyrtepistomus subcosticollis* Mshl.

KEY TO THE SPECIES OF GENUS *THLIPSOMERUS* MSHL. KNOWN FROM INDIA

1. Elytra covered with brownish scales, along with three transverse bands of piceous and some patches of whitish scales; scape abruptly clavate ..... *nigromaculatus* sp. nov.

   —Elytra covered with dull-brownish and a few patches of only whitish scales; scape gradually clavate 2

2. Intervals of elytra covered with broad, subrecumbent, short, fuscous and brown setae; funicle with joint 2 only a little longer than joint 1..... *subcosticollis* Marshall.

   —Intervals of elytra covered with stiff, erect, long and brownish setae; funicle with joint 2 distinctly longer thaa joint 1----------
   ..... *darjeelingenis* sp. nov.

1. Thlipsomerus subcosticollis (Mshl.) (Figs. 1, 2, 3)

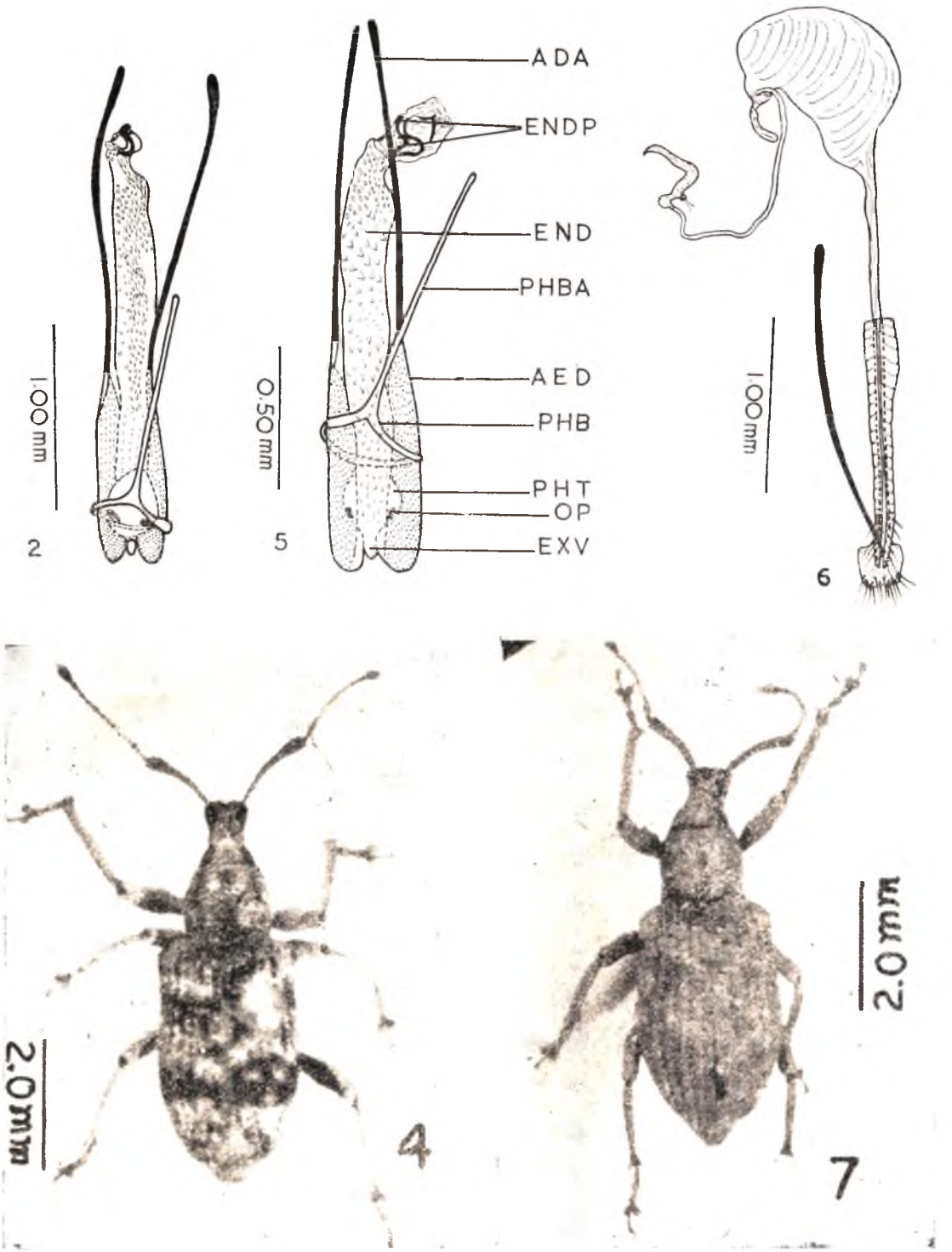
Marshall, Ann. Mag. Nat. Hist. (11) 10 p. 107 (1943) *(Cyrtepistomus)*; (11) 11, p. 90 (1944) *(Thlipsomerus)*.

The following information on the male and female genitalia is being added.

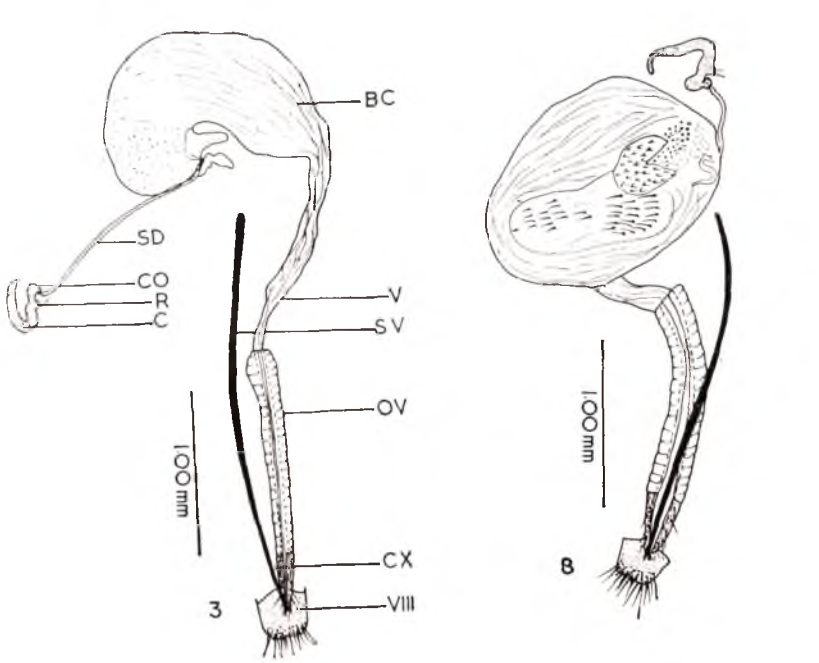
Male genitalia with aedeagus straight, bilobed at apex, with exophallic valve lying partly out of it; phallotreme subapical, with small orificial plates; aedeagal apodemes 1.7 times as long as aedeagus thin and slender, each gently curved at apex; phallobase ring shaped, its phallobasic apodeme somewhat longer than aedeagus; endophallus not surpassing aedeagal apodemes, beset with dense rows of setae and papillae throughout, much densely so subapically, with two pairs of curved plates at apex. Female genitalia with ovipositor long and weakly sclerotized, coxites more sclerotized and sparsely setose; bursa copulatrix well-developed, with a nipple-like process at apex; spiculum ventrale thin and long. Spermatheca with cornu pointed at apex, lying parallel to ramus.

2. Thlipsomerus nigromaculatus sp. nov. (Figs. 4, 5, 6)

Head with frons piceous, depressed, covered densely with brownish scales, wider than base of rostrum, its central fovea concealed by scales, with a row of few sub-recumbent spathulate setae by each eye; eyes black, large, circular and moderately convex. Rostrum fuscous, longer than its basal width, running parallel from base to scrobes and dilated towards apex; dorsal area, narrow, sulcate, covered densely with brownish scales and some suberect spathulate setae; interscrobal area bare, having two large foveae separated by a weak carina; dorso-lateral carinae covered with scales and almost obsolete in male,



2. Male genitalia of *Thlipsomerus subcosticollis* (Mshl.). 4. Photograph of adult *Thlipsomerus nigromaculatus* sp. nov. 5. Male genitalia of *Thlipsomerus nigromaculatus* sp. nov. 6. Female genetalia of *Thlipsomerus nigromaculatus* sp. nov. 7. Photograph of adult *Thlipsomerus darjeelingensis* sp. nov. (for abbriviations used, see Page 370).



3. Female genitalia of *Thlipsomerus subcosticollis* (Mshl.) 8. Female genitalia of *Thlipsomerus darjeelingensis* sp. nov. ADA ; Aedeagal Apodeme; AED : Aedeagus; BC : Bursa copulatrix; C : Cornu; CO : Collum; CX : Coxite; END : Endophallus; ENDP : Endophallic plate; EXV : Exophallic valve; OP : Orificial plate; OV : Ovipositor PHB : Phallobase; PHBA : Phallobasic apodeme; PHT : Phallotreme; R : Ramus; SD : Spermathecal duct; SV : Spiculum ventrale; V : Vagina; VIII : 8th sternum.

bare and distinct in female, strongly divergent towards apex; epistome short, its posterior margin forming wide obtuse angle, sloping steeply in front; scrobes broad, each delimited behind by an oblique carina, completely visible from above; mentum with 4 setae. Antennae fuscofumate, moderately long; scape curved, stout, gradually clavate for three-fourth of its length from base and abruptly clavate thereafter, exceeding front margin of prothorax, its surface covered with dense broad scales and stiff sub-erect fusco-fumate setae, setae more numerous towards apex; funicle with joint 2 longer than 1, and 3 and 7 subequal but shorter than 1, 4—6 subequal and shortest, all joints covered with elongated scales (except 6 and 7) mixed with long erect fusco-fumate setae; club oval and acuminate at apex, as long as three apical funicular segments, finely and uniformly pubescent.

Prothorax fuscous, transversely flattened, about as long as broad, its anterior margin subtruncate with well-developed ocular lobes bearing short vibrissae laterally posterior margin deeply bisinuate with median lobe acute; surface of pronotum uneven, marked with coarse punctures and each puncture with a sub-erect spathulate seta, scales brownish with a narrow central dark stripe and two broad light stripes of fumate scales in male only, as obtuse median costa in the basal half which is narrower and squamose in male and broader and bare in female, and a deep subbasal depression on each side limited

laterally by a low ridge; lateral sides rounded, broadest in middle, gradually narrowing to apex but not constricted, sinuate in basal half with the basal angles slightly projecting. Scutellum small, fuscous, oval, completely covered with brownish scales. Elytra fuscous, oblong, strongly declivous posteriorly; much wider at somewhat roundly rectangular shoulders than the prothorax, parallel sided but slightly wider behind middle in female, their surface covered with brownish and longitudinal bands and patches of white and piceous scales; striae formed by deep separated punctures almost concealed by scales, each puncture with a minute seta; intervals broad, with interval one elevated on apical half declivity, intervals three and five each with three long elevations (two before and one on top of declivity), each interval with sub-erect and spathulate setae more on and near the elevations.

Legs fuscous, covered with ochraceous scales and suberect setae, fore-coxae contiguous and placed in middle of prosternum; femora clavate, each with a small femoral tooth, their bases compressed and widened; tibiae slender, pro-tibiae feebly bisinuate internally, anterior two pairs with a row of spines on the inner apical half, apical end of each tibia with a fringe of fusco-piceous bristles and a mucro, corbels of hind tibiae open; tarsi setose, first joint of hind tarsi about 1.5 times as long as second, third bilobed joint as long as second and spongy beneath; claws free. Thoracic sterna closely beset with ochraceous scales alongwith some scattered sub-recumbent small and spathulate setae. Abdominal sterna densely covered with ochraceous scales and sub-recumbent setae.

Male genitalia with aedeagus straight, bilobed at apex, with exophallic valve coming partly out of it; phallotreme subapical, with very small orificial plates; aedeagal apodemes 1.5 times as long as aedeagus, thin and slender; phallobase ring-shaped, its ventral apodeme as long as aedeagus; endophallus not surpassing aedeagal apodemes, beset with dense rows of setae and papillae throughout, densely papillate sub-apically, with two pairs of curved plates at apex. Female genitalia with ovipositor long and weakly sclerotized, coxites more sclerotized and sparsely setose; bursa copulatrix more or less membranous with a nipple-like process at apex; spiculum ventrale long and thin. Spermatheca with cornu pointed and curved at apex, collum lying parallel to ramus.

Measurements:

Total length of male body:	5.1 to 6.2 mm.
-do- female body:	7.3 to 8.4 mm.
Width of rostrum of male:	0.5 to 0.6 mm.
-do- female:	0.6 to 0.7 mm.
Length of rostrum of male:	0.6 to 0.7 mm.
-do- female:	0.8 to 0.9 mm.
Width of head of male:	0.7 to 0.8 mm.
-do- female:	0.8 to 0.9 mm.
Length of head of male:	0.3 to 0.4 mm.
-do- female:	0.5 to 0.6 mm.
Width of prothorax of male:	1.1 to 1.3 mm
-do- female:	1.2 to 1.4 mm.
Length of prothorax of male:	1.05 to 1.2 mm.
-do- female:	1.15 to 1.30mm.
Width of elytra of male:	2.0 to 2.3 mm.
-do- female:	3.0 to 3.5 mm.

Holotype ♂; **Paratypes** 6 examples, 3 ♂♂, 3 ♀♀; INDIA, MEGHALAYA, Cherrapunji; collected from wild vegetation, C. S. Sidhu, deposited in collection of Entomology Section, Department of Zoology, Panjab University, Chandigarh.

Remarks: This species has a general resemblance with the species *subcosticollis* Mshl. However, the elytra of the male in the present species are covered over with a mixture of brownish, whitish and piceous scales as compared to the coating of dull-brownish scales having only a few patches

of whitish scales on the elytra of *subcosticollis* Mshl. Moreover, the intervals of elytra are beset with regular rows of closely placed sub-erect spathulate setae, whereas, such setae in *subcosticollis* Mshl., are recumbent, sparse and hardly distinguishable from the coating of the scales. The details of the genitalia structures also reveal important differences. For example, the aedeagal apodeme is relatively longer, exophallic valve narrower and the surface of endophallus more densely covered with denticles in *subcosticollis* Mshl., as compared to *nigromaculatus*. Likewise, the denticles are densely placed on bursa copulatrix of *subcosticollis* Mshl. whereas, these are scattered in *nigromaculatus*.

3. Thlipsomerus darjeelingensis sp. nov.
(Figs. 7, 8)

Head with frons shining black, flat, covered densely with brownish scales, and a row of few sub-erect setae near the eyes, its width more than base of rostrum, with central fovea deep and concealed by scales; eyes black, large, moderately convex, circular. Rostrum shining black, somewhat longer than its basal width, gradually narrowed from base to scrobes and then moderately dilated, at apex; dorsal area narrow, sulcate, densely covered with brownish scales and some recumbent spathulate setae, with the interscrobal area bare and bifoveate; central carina fine, terminal; dorso-lateral carinae fine, covered with scales, diverging and gradually so behind epistome; epistome short, with posterior margin not reaching the level of insertion of antennae; lateral areas densely squamose and longitudinally wrinkled; scrobes small, broad, each delimited behind by an almost transverse carina: mentum with 4 setae. Antennae fuscous, moderately long; scape curved, gradually clavate, reaching near middle of prothorax, its surface covered with dense broad scales and stiff sub-erect fuscous setae; funicale with joint 2 longer than 1, 3 and 7 subequal but evidently shorter than 1, 4—6 subequal and shortest, all joints covered with elongated scales, and long sub-erect setae; club oval, acuminate at apex, as long as three apical funicular segments, finely and uniformly pubescent.

Prothorax shining black, transversely flattened, about as long as broad, its anterior margin subtruncate and with well-developed ocular lobes bearing fine short vibrissae laterally, posterior margin bisinuate with median lobe acute; pronotum uneven, marked with coarse punctures almost concealed by scales, punctate with each puncture bearing a sub-erect spathulate seta, with an obtuse median costa in basal half which is narrower and somewhat squamose in male but broader and almost bare in female, with a deep rounded fovea behind middle on each side; lateral sides rounded, broadest at middle, narrowing towards apex but not constricted, sinuate in basal half with basal angles slightly projecting. Scutellum small. Elytra black, oblong, strongly declivous posteriorly, much wider at roundly rectangular shoulders than base of prothorax, running parallel from base to behind middle, slightly widened in female; striae narrow, formed by small distant punctures almost concealed by scales; intervals broad and flat but 1, 3 and 5 slightly raised, with a shallow transverse impression at one-fourth from base, covered with brownish and dull whitish very compactly placed scales, each interval with an irregular row of erect and moderately long setae.

Legs fuscous, covered with greyish and brownish scales and sub-erect setae; fore-coxae contiguous and placed in middle of prosternum; femora clavate, each with a small femoral tooth; anterior tibiae feebly bisinuate internally, anterior two

pairs with a row of spines on their inner apical halves, apical end of each tibia with a fringe of brown spines and a mucro, corbels of hind tibiae open; tarsi densely setose, first joint of hind tarsi 1.5 times as long as second and third bilobed joint as long as second and spongy beneath; claws free. Thoracic sterna black, covered with grey scales alongwith scattered sub-erect short setae. Abdominal sterna black, covered with brownish scales and short subrecumbent setae.

Male genitalia not studied. Ovipositor long and weakly sclerotized; coxites more sclerotized and setose; bursa copulatrix very well-developed, beset with setae and papillae, provided with a highly sclerotized bifid plate and a pair of curved plates near apex; spiculum ventrale long and slender. Spermatheca with cornu blunt and curved at apex, collum lying parallel to ramus.

Measurements:

Total length of female body	: 6.5 to 7.1 mm.
Width of rostrum of female	: 0.8 to 0.9 mm.
Length -do-	: 1.0 to 1.1 mm.
Width of elytra of female	: 2.3 to 2.5 mm.
Width of head of female	: 0.8 to 1.1 mm.
Length -do-	: 0.4 to 0.5 mm.
Width of prothorax of female	: 1.2 to 1.4 mm.
Length -do-	: 1.1 to 1.4 mm.

Holotype, 1 ♀, **Paratypes** 5 ♀♀ INDIA, WEST BENGAL, Darjeeling: collected from wild vegation, C. S. Sidhu, Material in Entomology Section, Department of Zoology, Panjab University, Chandigarh, India.

Remarks: This species also shows similarity with *Thlipsomerus subcosticollis* Mshl. and *Thlipsomerus nigromaculatus*. However, the setae on the intervals of elytra in *Thlipsomerus darjeelingensis* are distinctly thinner, suberect and widely scattered. In addition, the bursa copulatrix in *Th. darjeelingensis* is beset with denticles, whereas, *Th. subsosticollis* Mshl. and *Th. nigromaculatus* have only a nipple-like process near the apex of bursa copulatrix.

Genus Amrikus gen. nov.

Head with frons wider than base of rostrum; eyes somewhat convex. Rostrum somewhat longer than broad; epistome short, its margin carinate and forming an obtuse angle; mentum with 4 setae; Antenna with scape gradually clavate; funicle with two basal joints variable in length. Prothorax with posterior margin shallowly bisinuate, its basal angles at least with a small tooth or projection. Elytra with shoulders obiquely rounded; intervals 3 and 5 raised to from elevations; Legs with femora flattened and widened at bases; corbels of hind tibiae open; claws free. Male genitalia with aedeagus bilobed at apex, phallotreme subapical. Female genitalia with bursa copulatrix well-developed and sclerotized, spermatheca with collum completely directed towards ramus.

Type species *Cyphicerus deplanatus* Fst.

Remarks: The genus *Amrikus* differs from *Thlipsomerus* in the structure of rostrum, prothorax and female genitalia. Marshall (1944) had also indicated the hetrogenous nature of the species then assigned to *Thlipsomerus* which have been considered here a new genus. The differences are as follows.

Genus *Thlipsomerus* Mshl.	Genus *Amrikus* gen. nov.
1. A pair of fovea on rostrum behind epistome.	1. No such foveae present.

2. Basal margin of prothorax normal without any teeth or projection	2. Basal angles of prothorax with at least a small tooth or projection.
3. Elytra with intervals not raised.	3. Elytra with intervals 3 and 5 elevated.
4. Spermatheca with collum lying paralell to ramus.	4. Spermatheca with collum completely directed towards ramus.

KEY TO SPECIES OF *AMRIKUS* GEN. NOV.

1. Basal angles of prothorax produced obliquely backwards into long curved processes that reach shoulders of elytra; funicle with joint 2 longer than 1; phallotreme submedian ..... *deplanatus* Fst.

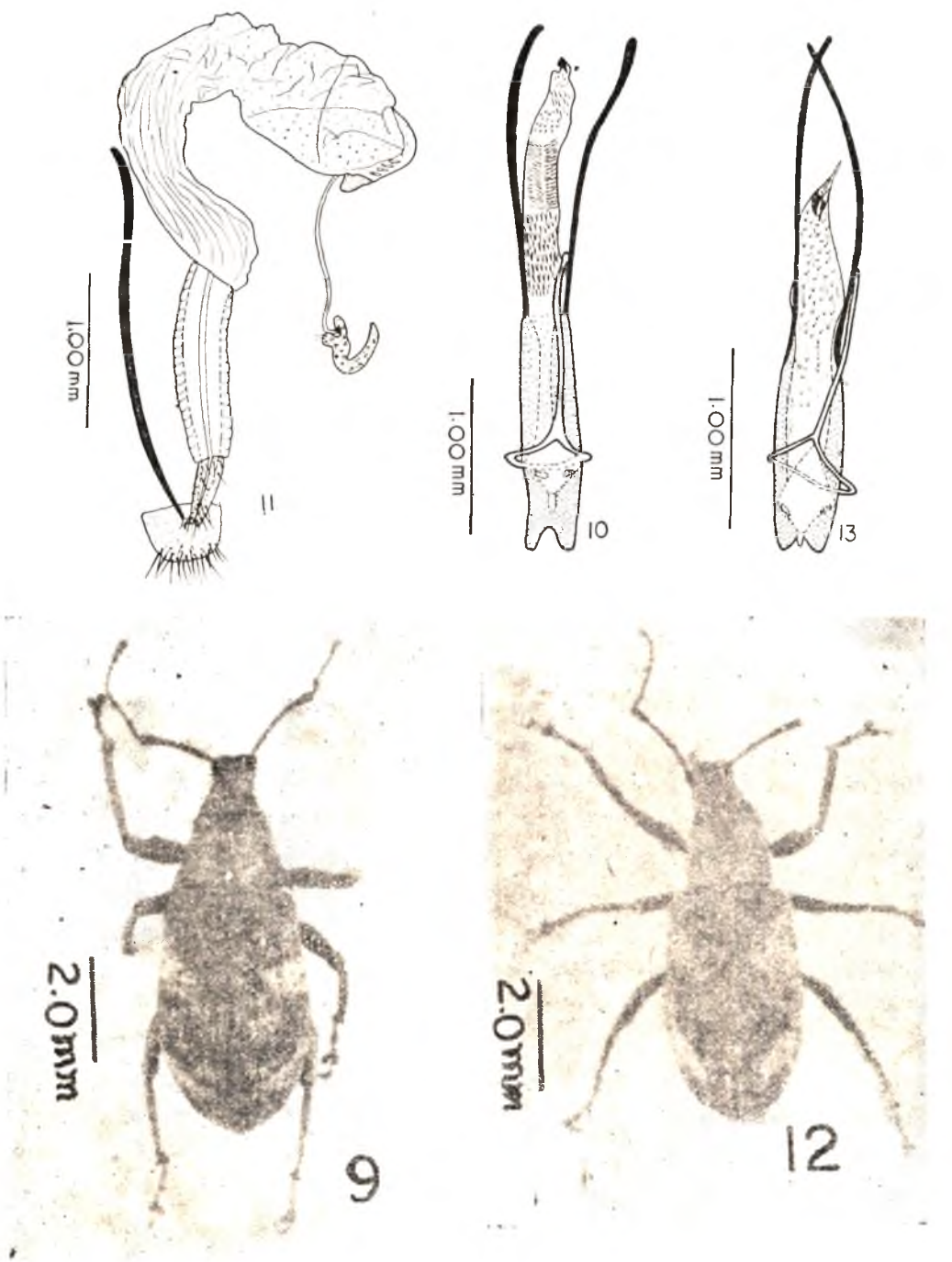
2. Basal angles of prothorax terminated each into a short sharp spine-like process; funicle with joints 1 and 2 equal; phallotreme subapical ..... *glebossus* Mshl.

4. Amrikus deplanatus (Fst.) (Figs. 9, 10, 11)

Faust, Stett. Ent. Zeit. II, p. 69 (1890) (*Cyphicerus*)—Schenkling and Marshall, Coleopterorum Catalogus, Pars 114, pp. 4, 35 (1981) (*Cyyhicerus*)—Marshall, Ann. Mag. Nat. Hist. (9) 13, p. 288 (1924) (*Cyrtepistomus*); (11) 10, p. 108 (1943) (*Cyrtepistomus*); (11) 11 p. 90 (1944) (*Thlipsomerus*).

Head with frons black, covered with brownish scales, a little wider than base of rostrum, lying a little above upper margins of eyes; central fovea deep and elongated, concealed by scales; eyes black, moderate, circular and somewhat convex. Rostrum black, somewhat longer than broad, running parallel from base to scrobes and moderately dilated towards apex; dorsal area broadly impressed, with an obsolete terminal central carina, covered densely by brown scales, with areas around epistome bare and more depressed; dorsolateral carinae distinct, parallel behind and diverging apically; epistome short, with strongly carinate margins forming an obtuse angle behind; lateral areas steeply declivous, squamose, each with two deeper sulci enclosing a broad low costa; scrobes broad, small, open curving inwards, almost visible from above; mentum with 4 setae. Antennae fuscous, moderately long; scape sub-cylindrical, gradually clavate, almost straight, reaching middle of prothorax, its surface furnished with elongated brownish scales and sub-recumbent brown setae; funicle with joint 2 longer than 1, joints 3 and 7 equal but shorter than 1, 4—6 equal and shortest, all joints covered with a few elongated brownish scales and numerous recumbent and sub-erect brown setae; club fuscous, fusiform, as long as two apical funicular joints, finely and uniformly pubescent.

Prothorax black, as long as its apical width, broadest at base its anterior margin sinuate with distinct ocular lobes and fine vibrissae laterally; dorsal surface uneven, flattened, distinctly punctate and each puncture with a very short recumbent seta not concealed by scales, densely covered with brownish scales; posterior margin shallowly bisinuate, with basal angles produced obliquely backwards into long curved processes reaching shoulders of elytra, with a large conspicuous depression at each angle. Scutellum fusco-piceous, rectangular, small, covered with scales. Elytra fuscopiceous, oblong, strongly declivous posteriorly, with weak shoulders; striae narrow, formed by shallow and separated punctures and each puncture with a minute recumbent seta, with interspaces densely squamose; intervals broad, with a shallow transverse inpression between striae 1—4 at one-fourth from base, intervals 3 and 5 elevated in



Figs. 9. Photograph of adult *Amrikus deplanatus* (Fst.). 10. Male genitalia of *Amrikus deplanatus* (Fst.). 11. Female genitalia of *Amrikus deplanatus* (Fst.). 12. Photograph of adult *Amrikus glebossus* (Mshl.). 13. Male genitalia of *Amrikus glebossus* (Mshl.)

basal halves, remaining intervals flat and covered with brown scales except two large patches of white scales (one before middle and one on declivity).

Legs fusco-piceous, very densely covered with pale and brown scales and suberect fine setae; fore coxae contiguous, placed in middle of prosternum; femora clavate, each with a small ventral tooth. its base compressed and widened; tibiae slender, anterior and middle tibiae with a row of spines on their inner apical halves, apical end of each tibia with a fringe of fuscous bristles and a mucro, corpels of hind tibiae open; tarsi densely setose, first joint of hind tarsus nearly twice as long as second, third bilobed joint as long as second and spongy beneath; claws free. Thoracic sterna covered with pale scales in middle and brown scales laterally, punctate and each puncture with fine brown setae. Abdominal sterna covered with pale scales in middle and brown scales laterally, punctate and each puncture with a suberect seta.

Male genitalia with aedeagus straight, tubular, bilobed at apex, with exophallic valve lying submedially, its sides and apex strongly sclerotized; phallotreme submedian, with small orificial plates; aedeagal apodemes a little longer than aedeagus, each gradually thickening towards apex and there gently curved; phallobase ring-shaped, with phallobasic apodeme shorter than aedeagus; endophallus lying between aedeagal apodemes, not surpassing them, beset with rows of dense spine-like setae and very small papillate subapically, with a pair of plates at apex. Female genitalia with long and weakly sclerotized ovipositor; coxites well sclerotized and sparsely setose; bursa copulatrix well-developed and sclerotized, with a pair of highly sclerotized plates at apex and a pair of small curved plates near base;

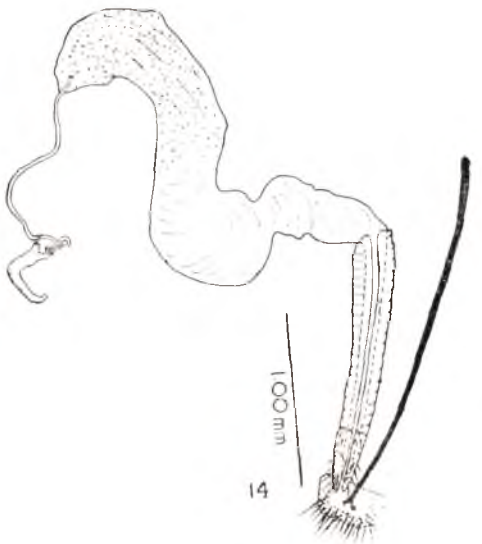


Fig. 14. Female genitalia of *Amrikus glebossus* (Mshl).

spiculum ventrale thick, long and gently curved. Spermatheca with cornu pointed at apex, collum completely directed towards ramus.

Measurements:

Total length of male body: 7.7 to 8.2 mm.
-do- female body: 8.0 to 8.6 mm.
Width of rostrum of male: 0.7 to 0.8 mm.
-do- female: 0.8 to 0.9 mm.
Width of head of male : 1.1 to 1.3 mm
-do- female . 1.2 to 1.4 mm.
Length of rostrum of male: 0.9 to 1.0 mm.
-do- female: 1.0 to 1.1 mm.
Length of head of male · 0.3 to 0.4 mm.
-do- female: 0.4 to 0.5 mm.
Width of prothorax of male: 1.4 to 1.5 mm.
-do- female: 1.5 to 1.6 mm.
Length of prothorax of male: 1.0 to 1.2 mm.
-do- female: 1.1 to 1.4 mm.
Width of elytra of male: 2.7 to 3.0 mm.
-do- female: 3.0 to 3.2 mm.

Redescribed from : 2 males and 3 females; INDIA, WEST BENGAL, Darjeeling, collected from wild vegetation, C. S. Sindhu. Material in Entomology Section

Department of Zoology, Panjab University, Chandigarh, India.

5. Amrikus glebossus (Mshl.)
(Figs. 12, 13, 14)

The following information on the male and female external genitalia is being added.

Male genitalia with aedeagus straight, bilobed at apex, with exophallic valve lying partly out of it; phallotreme sub-apical, with small orificial plates; aedeagal apodemes 1.5 times as long as aedeagus, thin and slender, each gently curved at apex; phallobase ring-shaped, phallobasic apodeme as long as aedeagus; endophallus not surpassing aedeagal apodmes, beset with dense rows of setae and papillae throughout, densely papillate sub-apically, with a pair of plates at apex. Female genitalia with ovipositor long and weakly sclerotized; coxites similarly sclerotized and sparsely setose; bursa copulatrix well-developed and sclerotized towards apex; spiculum ventrale long and slender. Spermatheca with cornu curved and pointed at apex, collum completely directed towards ramus.

Acknowledgements: The authors are grateful to U. S. Department of Agriculture and Indian Council of Agricultural Research for financing a five year project on Indian Curculionidae. They are also thankful to Mr. R. T. Thompson of British Museum (Natural History), London and Dr. P. K. Sen-Sarma of F. R. I. Dehradun for allowing the comparison of collection and for generous loan of material. The laboratory facilities provided by the Chairman, Department of Zoology, Panjab University, Chandigarh are also gratefully acknowledged.

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BRIEF COMMUNICATION

CONTAMINATION OF WATER IN RICE FIELDS SPRAYED WITH CARBARYL FOR INSECT CONTROL

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College of Agriculture, Vellayani

(Received 14 November 1981)

An experiment was conducted in the rice fields of Kuttanad to study the extent of contamination of irrigation water with carbaryl under two dosages applied as low and high volume sprays. The level of contamination was more in plots which received the high volume spraying. On the 10th day the residues got drastically reduced to levels of 0.05 to 00.2 ppm in the different plots.

(*Key words:* water contamination, carbaryl)

Insecticides applied for the control of pests in paddy fields are likely to pollute the irrigation water and this may also affect the fauna in the crop environment. The extent of this contamination with reference to the type of sprayers and the dosages of pesticides have not been studied in India. This paper reports the extent of contamination of irrigation water with carbaryl applied in rice fields of Kuttanad under different doses and as low and high volume sprays.

The crop was raised in statistically laid out (RBD) plots (5m × 4.5m) and was treated 30 days after transplantation with suspensions of carbaryl at doses of 0.63, 0.94, and 1.85 kg ai per ha. The high volume spraying was done with a hydraulic knapsack sprayer using 500 l of spray fluid per ha and the low volume spraying was done with a motorised knapsack sprayer using 150 l of spray fluid per ha. Water level in the field was maintained at 5 cm.

Residues of carbaryl in the water samples collected immediately after spraying and at 1, 4 and 10 days after application of the insecticide were determined by chemical assay. Samples were collected from different parts of each plot and was mixed together and 500 ml of it was drawn and processed. This was filtered through a strainer to remove coarse contents of soil and other sediments and then through a filter paper into a one litre separating funnel to which 150 ml of methylene chloride was added and vigorously shaken. The lower layer was then drained into 500 ml round bottom flask through a bed of 200 g of anhydrous sodium sulphate. This was repeated twice with fresh lots of 150 ml methylene chloride, but using the same sodium sulphate. The filtrate was mixed with 5 g of activated charcoal and filtered through Whatman No. 1 filter paper. The clean filtrate obtained was evaporated to 10 ml in air current at room temperature. A control sample also was extracted adopting the same procedure. The residues were estimated colorimetrically following the method of BENSON & FINOCCHIARE (1965). The recovery of insecticide in the method of estimation was found as high as 90-95 per cent.

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TABLE 1. Carbaryl residues in the irrigation water of rice fields sprayed for insect control.

Doses of carbaryl sprays (kg ai/ha)	Residues of carbaryl (ppm) in water samples collected at different intervals after spraying (days)			
	1/24	1	4	10
		High volume spray (500 l/ha)		
1.85	0.30	0.30	0.08	0.05
0.94	0.22	0.21	0.06	0.04
0.63	0.15	0.08	0.07	0.02
Mean	0.223	0.196	0.07	0.036
		Low volume spray (150 l/ha)		
1.85	0.18	0.16	0.10	0.04
0.94	0.09	0.07	0.06	0.03
0.63	0.07	0.07	0.04	0.03
Mean	0.113	0.10	0.07	0.033

The residue levels in the samples were determined using a regression equation obtained from the optical densities of the graded concentrations of 0, 10, 20, 40, 80 and 100 ppm of technical grades of carbaryl.

Data presented in Table 1 showed that residues in samples collected one hour after ranged from 0.15 to 0.3 ppm under high volume spraying and 0.07 to 0.18 under low volume spraying. These levels of carbaryl residues are not likely to harm the fish fauna in the field since the TLm levels found for fishes by earlier workers were much higher than these levels (BHATIA, 1971; RITA & NAIR 1978). But even very low doses of insecticides (up to 0.001 ppm) are reported to affect the breeding behaviour and spawning of fishes under laboratory conditions (KONAR, 1979).

The level of contamination under high volume spraying was almost double than that of the low volume spraying. The residues did not disintegrate significantly during the first twentyfour hours after spraying. But within the next three days the residues got drastically reduced in more contaminated plots and at the end of 4th day the levels in all the plots came on par and much lower than the previous occasion. On the 10th day the residues got degraded to the levels of 0.05 to 0.02 ppm in the different plots.

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RHOPALOSIPHUM NYMPHAEAE (LINN.) HOMOPTERA : APHIDIDAE, A CONTROL AGENT FOR *SALVINIA MOLESTA* (MITCHELL)

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(Received 27 June 1982)

Rhopalosiphum nymphaeae (Linn.), the water lily aphid, has the ability to effectively check the growth of *Salvinia molesta* (Mitchell). Studies made for a period of three months on the destructive action of the aphid on *Salvinia* showed that it sucks off the Juice from leaves causing withering, followed by growth retardation and loss of folding tendency, thereby halting the characteristic overcrowding. In about six to eight days the affected leaves exhibit large scale tissue degradation followed by rotting, thereby checking the spread of the weed.

(Key words: Rhopalosiphum nymphaeae, Salvinia molesta, biocontrol)

INTRODUCTION

The rapid proliferation and dense growth of the 'African fern' *Salvinia molesta* in fresh water bodies especially paddy fields, ponds, canals, irrigation systems etc. of Ernakulam, Alleppey, Kottayam, and Quilon districts and the hydro-electric reservoirs have led to serious problems and much concern. The various chemical and biological methods suggested and adopted from time to time for the control of this weed have proved ineffective even for the partial control of this weed. Chemical methods have the disadvantage of leaving behind poisonous residues in the habitat, thereby causing pollution problems. The conventional method of mechanical removal appears to be the only one effective so far. However, in terms of cost of labour and time involved, this technique is quite expensive and is purely of a temporary nature. Biological control of *Salvinia* has clear economic and environmental advantages over other methods of control. Earlier attempts in this direction have been only partly successful or unsuccessful owing to various ecological factors.

Three species of insects, the beetle *Cyrtobagous singularis* Hustache, the moth *Samea multiplicalis* (Guenee) and the grasshopper *Paulinia acuminata* (De Geer) have hitherto been tried as agents of biological control of *Salvinia*. Very recently ROOM *et al.* (1981) have reported successful control of the largest *Salvinia* infestation in Australia using *Cyrtobagous singularis* and suggested its possible use in countries such as Africa, India, Sri Lanka, Indonasia, Papua New Guinea, New Zealand and Fiji.

Our studies in Trivandrum have shown that the water lily aphid, *Rhopalosiphum nymphaeae* (Linn.) Homoptera: Aphididae, is quite effective as a control agent both under laboratory and in small confined field conditions. The advantage of this species is that it occurs indigenously.

MATERIALS AND METHODS

Specimens of *R. nymphaeae* were collected from a wild variety of *Amaranthus* growing near the water bodies in Paipadu, Alleppey district, Kerala State. On November 7, 1981, 250 specimens were released onto a single uniformly floating layer of the late proliferating stage of

Salvinia kept in a cement cistern 2.25m². Observations were continuously made for a period of three months. An identical tank with the same growth stage of *Salvinia* was kept as control.

RESULTS AND DISCUSSION

On release into the aquarium tanks, the aphids settled on the leaves and began to suck the sap avidly (Fig. 1). The first visible symptom of the infestation was the withering of the 'hairs' on the surface of the leaves. This was followed by the gradual loss of freshness and turgescence of the leaves and further growth of the leaf was visibly hampered. The leaf lost its characteristic folding tendency thereby halting the overcrowding which is very typical of this fern in a confined area. This soon led to a situation in which the fern appeared to remain stunted in growth with a protracted floating stage (Figs. 2-3). In about six to eight days the affected leaves turned brownish in hue with obvious signs of tissue damage and eventually the leaves began to rot and get waterlogged without attaining full growth (Fig. 4). In case of attack on fresh, fully formed leaves, the natural green tint gradually faded out and the leaves became brownish in hue.

During close observations for a period of three months, it was found that colonies of *Salvinia* attacked by this aphid are unable to attain the full growth which they would normally attain within a period of about 30 days (GAUDET, 1973).

R. nymphaeae is widely distributed and is known to overwinter on hosts such as plum and prunes and spend the summer in aquatic and semi-aquatic hosts such as *Lemna*, *Nupher* and *Zizamia* sp. In Meghalaya, the species is mostly known from *Nymphea* and *Vallesnaria* (BISWAS & GOSH, 1981). However, these insects are also noticed on the stems of certain succulant plants such as *Amaranthus*, from which it has been collected for the present study. In Kerala parthenogenetic viviparous aptera and alata have been observed, the latter being less common.

From our observations it would appear that *R. nymphaeae* has the ability to effectively check the growth of *Salvinia* and that this insect could naturally be listed as a very useful agent for the biological control of the fern. The exact role played by *R. nymphaeae* is not yet clear. Whether the destruction is a function of the feeding intensity of the aphid and/or the transmission of some disease causing virus has yet to be ascertained. The latter suspicion is on account of the fact that *R. maidis* (Fitch) and *R. padi* (L.) which are sometimes serious pests of cereal crops, have been shown to be vectors of virus diseases (RICHARDS, 1960).

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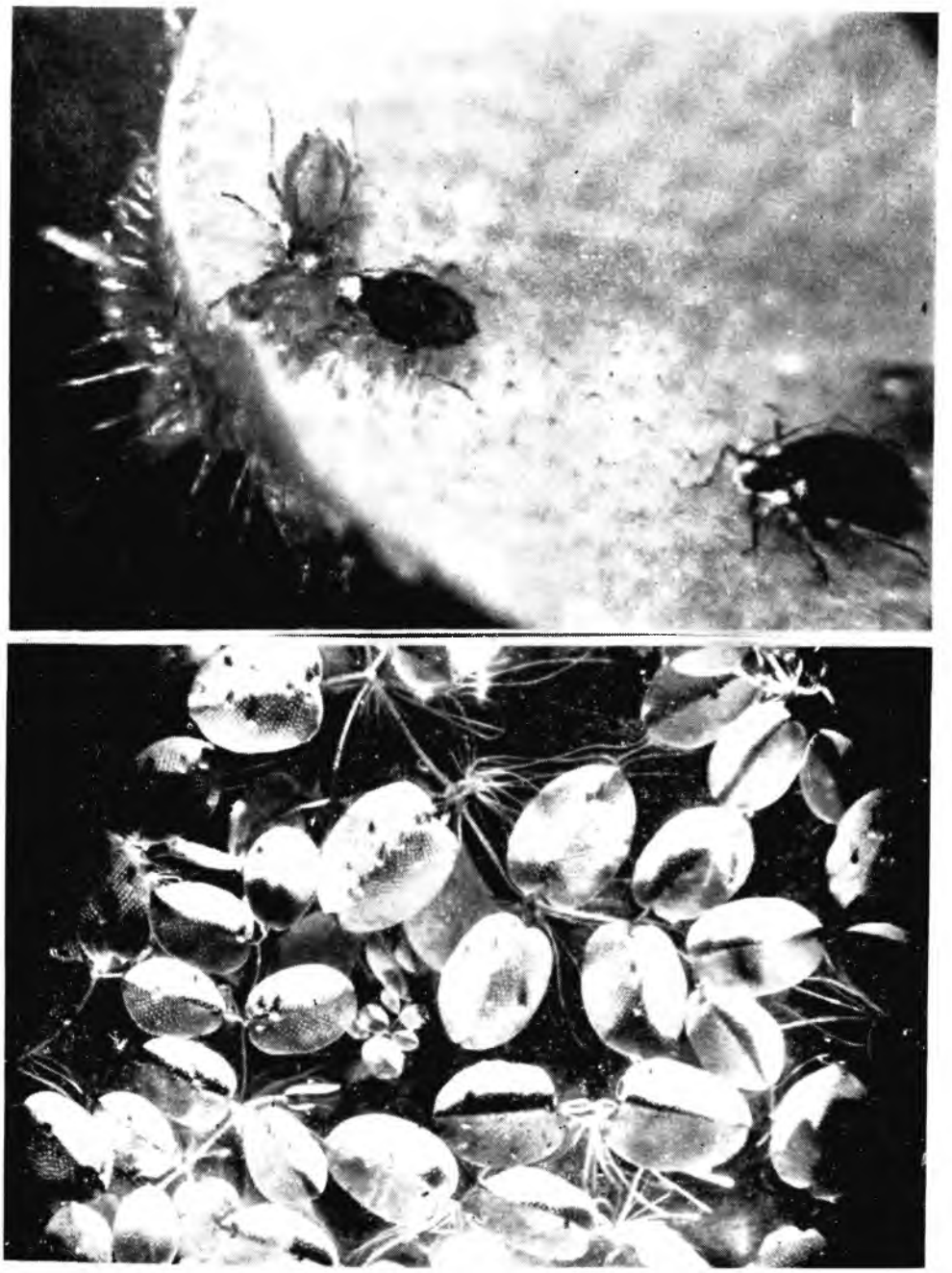

Fig. 1. Close up of the leaf surface of *Salvinia molesta* showing the aphid feeding on the sap.
Fig. 2. Proliferating stage of *S. molesta* showing the attack of *Rhopalosiphum nymphaeae*.

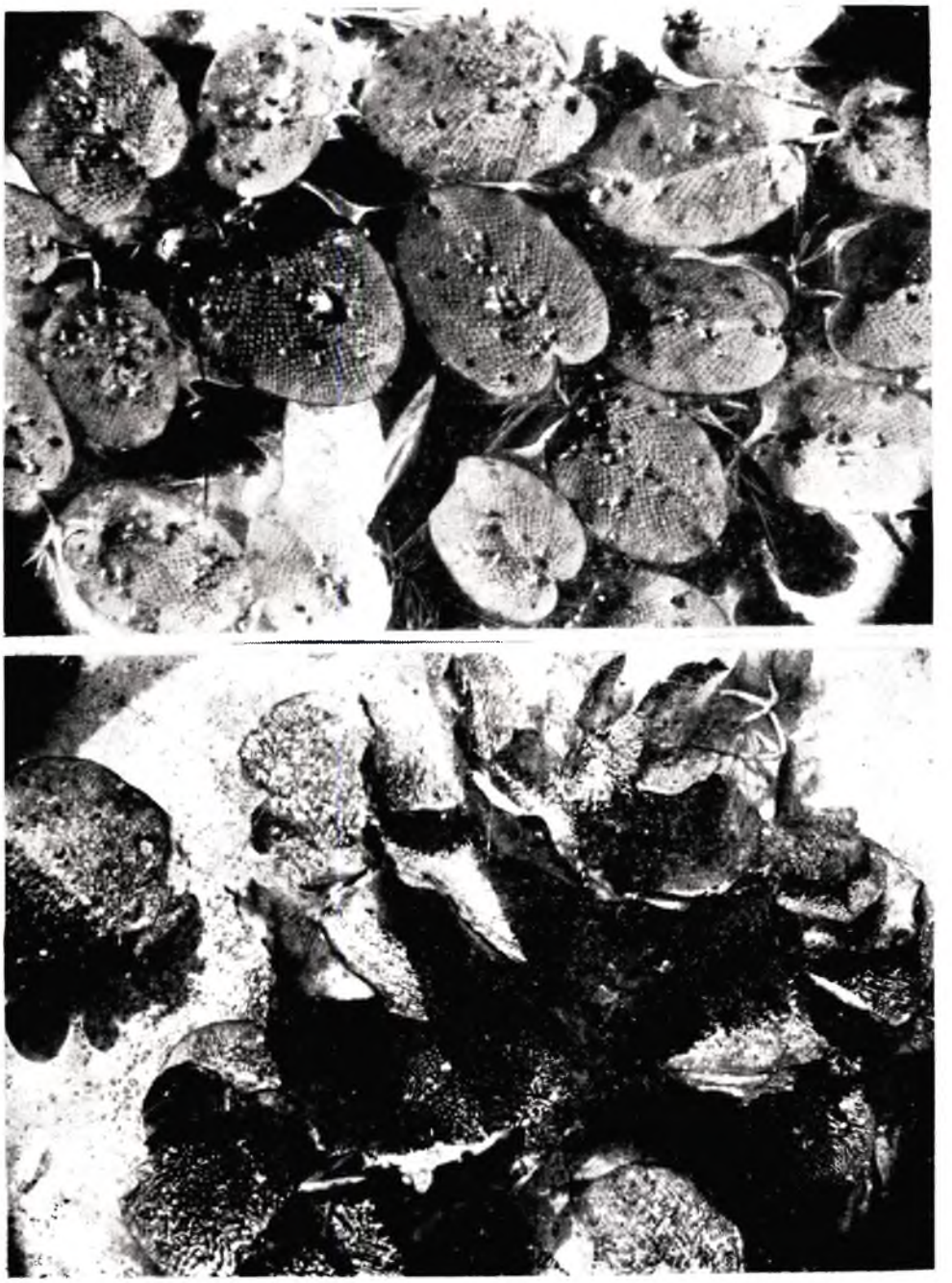

Fig. 3. A later stage of attack by *R. nymphaeae* showing the arrested growth of *Salvinia*.
Fig. 4. The rotting waterlogged leaves after the attack by *R. nymphaeae*.

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